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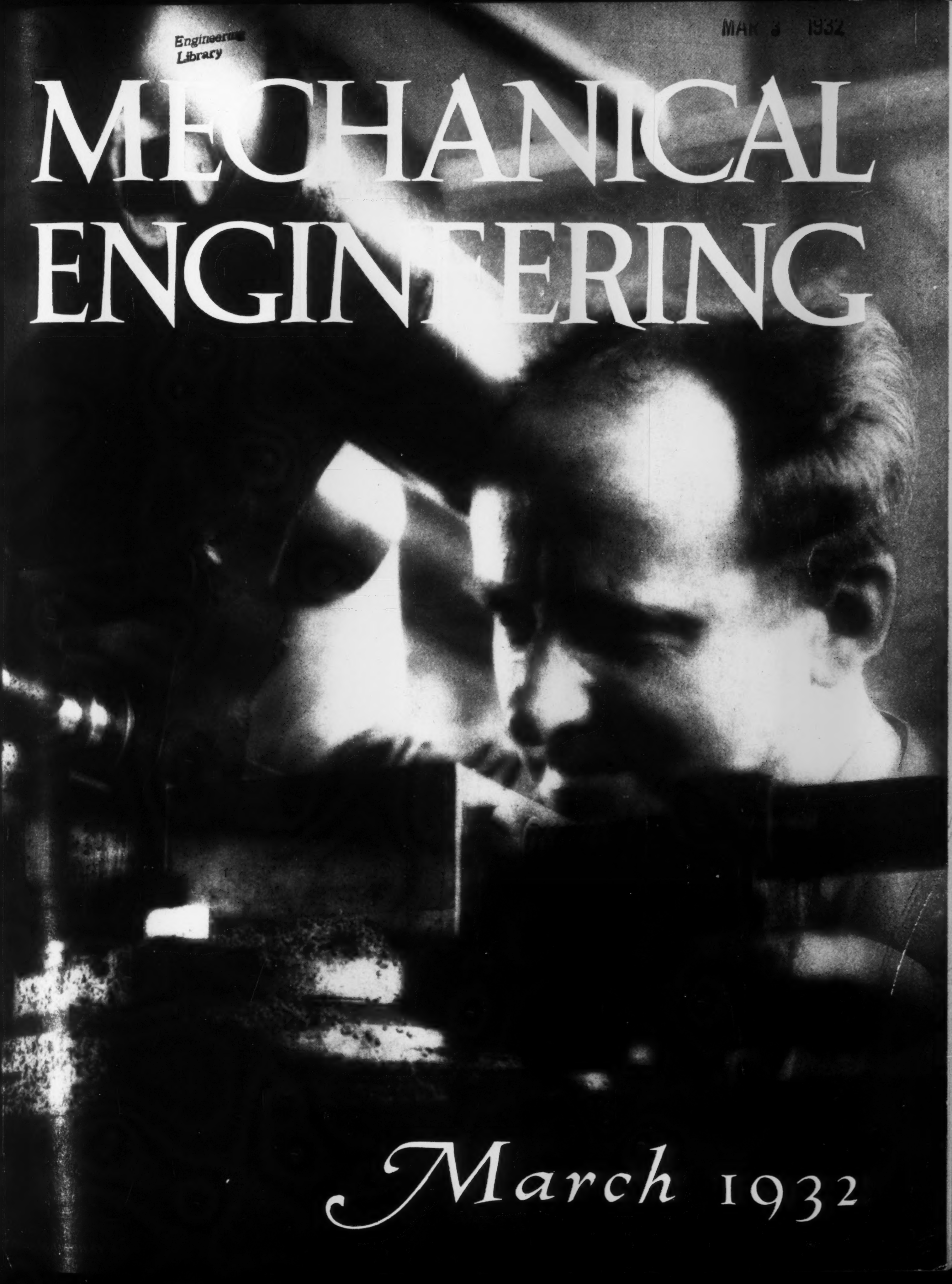

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MECHANICAL ENGINEERING

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WHAT IT'S ALL ABOUT

WHEN a great and complicated machine breaks down or functions badly, engineers take a natural interest in it and are likely to look into the fundamental reasons for the trouble. Society is such a machine. Never a perfectly operating mechanism, it creaks, groans, falters, and breaks its parts more frequently at some times than at others. Today it seems to be a chaotic wreck. In few places in the world is it functioning normally. In most of the larger countries it seems hopelessly out of gear. More insistently during recent months, but always by thoughtful persons, the machine and its troubles have been the subject of careful study, and if good can come from misfortune it may transpire that adversity may yet disclose its "sweet uses" and become the harbinger of better times.

Students of our social system have advanced unnumbered reasons, primary and contributory, for the breakdown of its functions, and a frequently mentioned group of causes is laid on the doorstep of the engineer. Now engineers may refuse to open the door and acknowledge their responsibility; they may protest loudly their innocence; but the more thoughtful of them will blind themselves neither to the fact nor to its implications, but will "see truth dawn together" in a study of the charges and thereby develop their understanding.

HERBERT CLARK HOOVER

(A portrait unveiled February 15, 1932, at the Engineering Societies Building, New York, where it will hang permanently. Painted by Philip A. de Laszlo, of London, at the request of the Civil, Mining and Metallurgical, Mechanical, and Electrical Engineering Societies. President Hoover is an Honorary Member of each of the four Societies.)

LAST December, having in mind generally the world's economic and social ills, and addressing himself to members of the scientific honor Society of the Sigma Xi at the Annual Meeting of the American Association for the Advancement of Science, C. F. Hirshfeld undertook to answer the question, "Whose Fault?" by placing an uncomfortable share of the blame upon the shoulders of scientists and engineers.

Mr. Hirshfeld is a practical sort of thinker. He works and lives in an atmosphere of rapidly changing and very novel ideas. Many of these ideas are so new and strange that they would be condemned without investigation by a less perspicacious man, but with keen analytical thinking, logical imagination, and that powerful tool of modern progesss, research, Mr. Hirshfeld tests the ideas that come before him with the persistent zeal that characterizes searchers after truth. When he speaks, engineers must perforce listen.

"I am convinced," he says—and his complete address is the leading article of this month's MECHANICAL ENGINEERING—"that the major ills of the world today and for some time past are due largely to those of us who have advanced science and the application of science, and,"—now we come to the most unkindest cut—"who have almost criminally refused to give serious thought to the collateral results."

This wholesale indictment challenges every engineer, and is based upon a conception of professional obligations and responsibilities that MECHANICAL ENGINEERING has emphasized consistently.

MR. HIRSHFELD is not one of those who sigh for Edenic innocence and a return to the so-called golden ages of the past. He recognizes as keenly as any one the astounding advances that science and engineering have made possible in society, and the enormous rise in the standard of living that has come as a result. But he has not blinded himself to the rank crop of economic and social problems that have developed as the collateral results of these material blessings.

Research is the means by which we shall solve these problems, and so, while Mr. Hirshfeld gives engineers and scientists a large order, he provides them and others who have a more immediate concern with economic and social evolution a tool by means of which they may be able to fashion none but beneficial products from the raw materials provided by the progress of science.

TWO important implications, among others, follow from Mr. Hirshfeld's argument. First is the increased importance and significance of engineering in the social and economic world. Second is the growing demand for men of high character and broad human sympathies and understanding to make up the profession of engineering. The profession is no greater than its practitioners, and their quality depends upon the character of the men inducted into it, the ideals they hold, and the education they receive. None but the best will do, for as time goes on the world will expect more of the engineer. Not only upon his knowledge and skill, but upon his wisdom to put these to good use, does real progress depend.

THAT Mr. Hirshfeld is not alone in his answer to the query, "Whose Fault?" is proved by the opening sentence of R. H. McCarthy's discussion of a specific instance of the interplay of professional and social factors involved in the serious disturbances caused by distinct efficiency gains. These gains have been economically justifiable in most cases, but in many instances they have resulted in throwing men out of work. One point of view on this problem was expressed in Mechanical Engineering for January, 1931, by Elliott Dunlap Smith, who, working with the Yale Institute of Human Relations, has applied the research method recommended by Mr. Hirshfeld to social problems. Mr. McCarthy discusses another phase of the problem.

TACKLING an economic aspect of the broad questions raised by Mr. Hirshfeld, W. H. Rastall, chief of the Machinery Division of the Bureau of Foreign and Domestic Commerce, gets right down to brass tacks and statistics in a survey of the machinery industry's reactions to the business cycle. Inasmuch as a majority of mechanical engineers are mixed up in the machinery industry in one way or another, Mr. Rastall's study of their problem should prove enlightening and stimulate some constructive thinking.

APPARENTLY it is impossible to get away from Mr. Hirshfeld's article, for the present issue of Mechanical Engineering contains another paper related to it. G. L. Studley, in a paper entitled "Economic Lot Sizes," applies mathematics to the determination of economic production quantities. He bases his paper on the work of Prof. Fairfield E. Raymond, of M.I.T., which deserves throughtful study as the basis of a rational approach to problems of production, capital investments, replacements, etc.

AND so we have worked ourselves down to two papers of more purely technical interest—one, by W. J. King, on "Heat Transmission," the first of a series that will present the most recent knowledge on this important subject, and the other, by J. H. Keenan, on a "Steam Chart for Second-Law Analysis" which will find wide application in problems where thermodynamic availability is a controlling factor.

TWO ENGINEERS HONORED

(Dr. Michael I. Pupin, Electrical Engineer and Inventor (seated), and Dr. Edwin Wilbur Rice, Jr., Honorary Chairman of the Board of the General Electric Company (standing), holding the medals conferred upon them at the recent convention of the American Institute of Electrical Engineers. Dr. Pupin received the John Fritz Medal, and Dr. Rice the Edison Medal.)

WE CANNOT emphasize too strongly nor in too many ways the function that Mechanical Engineering is trying to perform. By means of articles of broad appeal, so brilliantly illustrated this month by Mr. Hirshfeld's Sigma Xi address, it attempts to bring together all engineers in an analysis of common interests. By its strictly technical articles it makes a contribution to the literature of mechanical engineering. Through the Survey, the Synopses of A.S.M.E. Papers, and the selected items from the Engineering Index it presents a broad panorama of the literature of the profession that is available in other technical periodicals received by the Engineering Societies Library. It is the policy of the editors to apportion these diverse elements of the general and the specific as skilfully and as intelligently as possible, and to maintain a well-balanced "ration" every month, relating the contents as closely as possible to what is going on in the world and to the needs of all readers.

EWING GALLOWAY, N.Y.

Could Watt Have Known What Steam Would Mean to the Modern World?

WHOSE FAULT?

By C. F. HIRSHFELD[1]

I believe I am right in assuming that this cloud is of our own making, and that it will continue to oppress us until we have the sense and the ingenuity and the determination to apply the research method to those larger problems that we unwittingly created and nurtured as we applied that tool to its more simple and more obvious uses. . . . I am convinced that the major ills of the world today and for some time past are due largely to those of us who have advanced science and the application of science, and who have almost criminally refused to give serious thought to the collateral results. To my mind it is our fault that a civilization capable of producing a surplus of foodstuffs, of material goods required for living, and even of luxuries, a civilization capable of yielding surplus earnings and leisure time to all who are willing to work, finds itself beset by all sorts of little-understood economic upheavals, wars, and social rebellions. But I am satisfied that we can do much to make this collection of peoples happier and their lives much more worth while if we will make an honest attempt to apply the research method to the solution of that large class of problems involving huge masses of people.

WE ARE in the midst of one of those cataclysmic happenings which lead us to question the navigating abilities of those in charge of our ships of state and of our ships of commerce. We as a nation have been plunged rather suddenly from a state of comparative prosperity and bliss to the depths of a depression. Without study of earlier similar happenings we are all perfectly willing to admit that this particular depression is without parallel. To make matters most complicated, we find that the phenomenon is practically worldwide. Something has upset this machine that we have built with such an outlay of brains and brawn. Now, in characteristic fashion, we are engaged in asking whose fault it is that we find ourselves thus submerged in a maelstrom of destruction. Certainly we should like to discover what measures are required to raise us out of the present depths and to prevent the recurrence of such a frightful and horrible experience, if we succeed in surviving this one.

The question is on every tongue, it appears in our newspapers and periodicals, it is the talk of the market place, the public square, the business office, and the home. And, as usually happens, there are almost as many explanations as there are individuals with sufficient temerity to express themselves on the subject.

MAJOR HAPPENINGS IN AFFAIRS OF MEN NOT SPONTANEOUS

A minute's thought will convince you that major happenings in the affairs of men are not spontaneous; such occurrences generally represent the easily observable consequences of more or less submerged and unnoticed movements which have been long in existence. Sometimes the period is measured in years, sometimes in centuries, and sometimes in milleniums. One of our great weaknesses is that, even if we recognize the necessity of looking to the past for explanation of the present, we are prone to look only to the most recent past. In many cases it is necessary to go back to much more remote periods.

I may illustrate this statement with a reference to that which the majority of this audience represents: namely, science. Confronted with a mass of scientific knowledge of colossal magnitude which has been produced within a few short decades and much of it since the beginning of the present century, the man in the street regards science as a very recent development. You, who know its history, realize that it has its roots so far back in human experience that we find traces of it, in one form or another, in many of the earliest civilizations of which we have record. That which appears today in all its glory is not a spontaneous development of our era; it is but one phase of a long evolutionary process. And those of you who are scientists will readily agree that our present-day science does not mark the end of this evolution, is not its culminating phase.

May it possibly be that many of us who have been studying the phenomena of the present disturbed condition of world affairs and who have attempted to explain them have confined our attention too much to recent events and have ignored too greatly certain earlier happenings? To my mind one cannot properly place the blame for the present conditions without considering events depicted in a long movie film, whereas most of us are satisfied to study only a few of the most recent exposures.

In my view it is necessary to pick up the study of this film at least as far back as about 1500 A.D. Somewhere about that time begins the development of what may be called modern science and modern scientific methods. I believe that at about that time man began to recognize, in a general sense, the significance of what we now call the research method of advancing knowledge. Since then we have accumulated information regarding natural phenomena at an ever-increasing rate, and we have builded a structure of which we may well be proud.

---

[1] Chief of Research, The Detroit Edison Company, Detroit, Mich. Mem. A.S.M.E.

Sigma Xi Lecture delivered at the Annual Meeting of the American Association for the Advancement of Science, New Orleans, La., December 29, 1931. Slightly abridged.

While this great succession of original thinkers and workers of which you are now a part has been busily engaged in determining the facts about the universe in which we live, in lifting man out of the abysmal ignorance in which he appears to have been set upon this globe of ours, another equally fervent group has been engaged in an equally significant endeavor. Your group may well be designated as the scientists; or, possibly, the natural scientists; it is not so easy to find a comprehensive name for the other. Perhaps appliers of science or utilizers of science will serve. The group is made up of inventors, engineers, doctors of medicine, agricultural experts, and so on through a long list. It is composed of those who take the findings of the scientist and apply them to human affairs. This group, like yours, utilizes the research method as a means of advancing knowledge and the application of knowledge.

For the purpose of illustrating what I have to say to you, first I shall ask you to transport yourself mentally back to the Europe of the eighteenth century, when the flower that men like Galileo had planted was just beginning to blossom with the science that we know today, and when the engineer and other appliers of scientific teachings were beginning to work in a large way. Think of the changes that successively passed over the face of Europe as these pregnant developments occurred as the so-called industrial age unfolded. Recall the way in which the tool that we now call the research method opened up ever-widening fields of knowledge and ever-increasing possibilities for the practical application thereof. And realize that such practical applications spelled opportunity and wealth then as they do now.

Now, please remember that, at the beginning of these happenings in Europe, this nation of ours was a simple, agricultural state, very young, very small, and very poor. That which is now our country had been partitioned among the powers, as had the rest of the world. By various means we acquired first one part and then another, until finally we discovered ourselves in possession of a huge empire, all in one piece. It contained almost all that the heart could desire: tremendous areas ideally suited to agricultural pursuits of many varieties, wealths of minerals of all sorts, climates varying from the most rigorous to the near-equatorial, game in abundance, and, best of all, room for all and for many more.

We did not need to trouble over the shifting boundaries of Europe, over its jealousies and competitions, over its highly entertaining though fearfully serious check and countercheck. And we did not.

UNDREAMED-OF DEVELOPMENT OF APPLICATIONS OF SCIENCE IN AMERICA

In such an atmosphere the application of science found an opportunity to develop in a way not previously dreamed of. Size and quantity limitations were very largely absent, and big thoughts sprang up in the minds of big men, untrammeled by the constricting conditions existent in Europe. It was a glorious existence. We lived, in general, at peace with our neighbors; we waxed wealthy, but continued to possess sufficient vigor to keep us from getting fat and flabby.

We had, to be sure, our periods of economic ill health, but we were young and possessed of that youthful vigor which spells early convalescence and rapid recovery. We made our mistakes, but they were swallowed up in our successes. We boomed along in a blissful, easy, youthful fashion without many serious cares and without any real appreciation of the worries of our elders across the water.

THE DEBACLE

And then the heavens fell! Suddenly Europe was convulsed. Her soil rang to the tread of armies of unbelievable size, and the air was rent with explosions of unprecedented magnitude and number. All was confusion.

And while we watched we had the opportunity to make several startling discoveries. One, and not the least, was that just as Europe started this grand conflagration, our own country, for some inexplicable reason, slowed down. Were we in fact in some way so intimately tied to the Old World that its troubles could have such an immediate effect upon us?

Before we had really had time to digest this horrible thought and to weigh its consequences, the belligerents found their own resources inadequate and came to us for ever larger supplies. In our youthful enthusiasm we entered heartily upon this new game. After these curious and apparently crazy people in Europe had sent us all of their own wealth that they could possibly break loose for that purpose, we had a plenitude. Why not lend it back to them, and then let them pay us with it? And so we went blissfully on our way, getting richer and richer in the possession of promissory notes of different sorts.

And then, after voting conscientiously and overwhelmingly to keep ourselves out of the war, we suddenly found ourselves in the thick of it.

During this period we made two discoveries. The first was that our Government needed untold billions of dollars to carry on this queer game in which we had somehow become enmeshed. The second was that these undreamed-of sums could actually be obtained by borrowing from everybody in the country in exchange for Government promises to pay.

Finally, the outward and easily visible signs of the storm ceased. We with our newly found companions in arms reached agreement with our erstwhile opponent and called the whole thing off. And then we all endeavored to pick up our lives where we had left them before the storm. But we found ourselves most alarmingly changed. We had become the world's bankers. Where before we had in various ways been a huge borrower, we now found ourselves a huge lender. We found that, whether we liked it or not, we had to grow up rather suddenly and to give serious thought to those problems on the other side of the water that had always seemed so foolish and meaningless to us.

THE RUDE AWAKENING

To say the least we had a rude awakening. But after all, we possessed duly elected and properly appointed individuals whose business it was to handle such knotty problems. Why should we worry about them ourselves? We still had plenty of money. We had recently discovered what the population of the country could produce in exchange for properly executed promises to pay.

JAMES WATT

We soon discovered the fallacy of many of the old and threadbare teachings of business and of economics. We discovered that land need not be purchased with any regard to its value for a specific purpose in a specific community, or with any consideration of competitive land values. We found that stocks, representing equities in industrial enterprises, need not be purchased with any regard for present earning capacity and dividend-paying ability. We found it unnecessary to keep production within the present capacity of the consumer to pay. Take his note for future payment during the course of the next two or three years. In some miraculous way he will continue to earn more and more and be able to go more and more into debt in order to keep the wheels of industry turning at an ever-increasing rate. And, if he tires of this sort of thing, if he shows signs of fag, just titillate his acquisitive spirit with new designs which will cause him to throw away his obsolete and only partly-paid-for acquisitions.

LOUIS PASTEUR

FROM THE WORK OF WATT, OF WHITNEY, AND OF PASTEUR INCALCULABLE RESULTS HAVE SPRUNG—UNLIMITED MECHANICAL POWER, QUANTITY PRODUCTION OF GOODS AT LOW COST, AND THE SAVING OF MILLIONS OF LIVES FROM THE RAVAGES OF DISEASE. THE PROBLEMS THAT HAVE ARISEN IN THE WAKE OF THESE AND OTHER GREAT DISCOVERIES CAN BE SOLVED BY THE METHODS OF SCIENTIFIC RESEARCH

And what ended this merry round? To my mind our downfall was due principally to a very sudden return of sanity. Some of us suddenly thought of questioning the assumptions on which we were proceeding. That was all that was necessary. Just as soon as we seriously questioned the idiotic instruments of credit and other sorts of paper that we had been accepting at face value, we discovered that many of them were well-nigh valueless.

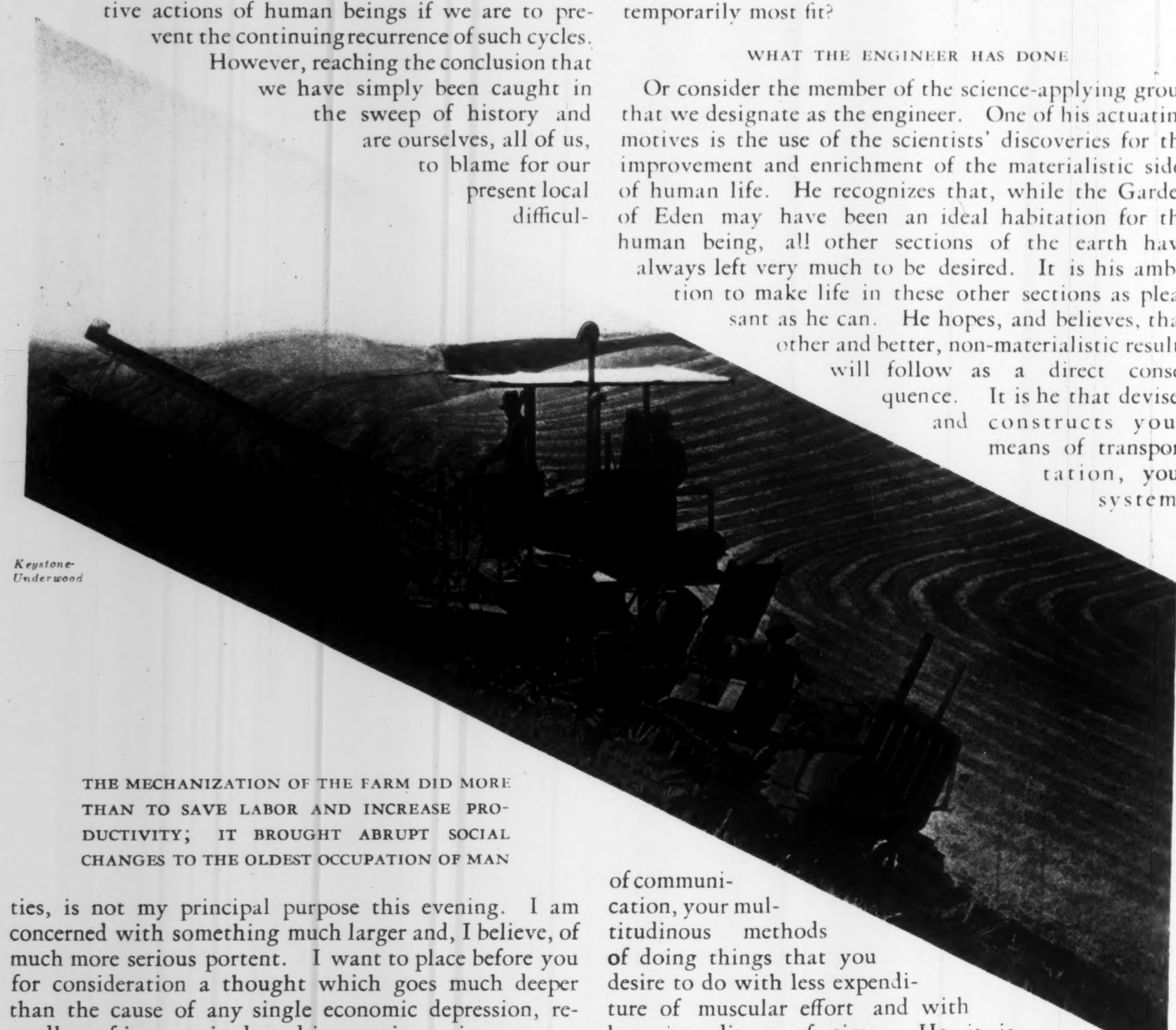
You see, I answer the question of who is responsible for our present local difficulties very simply by saying "Ourselves," you and I, and the rest of us.

ECONOMIC LAWS BUT THE GENERALIZATIONS OF HUMAN PSYCHOLOGY

We discuss very seriously the possibility of eliminating the business

ELI WHITNEY

cycle and thus preventing the alternating periods of prosperity and depression that we are familiar with. We speak and act and think as though some sort of impersonal economic laws control such things, and we consider the possibility of modifying these laws or restricting their action so as to level out these industrial hills and valleys. But, to me economic laws are but generalizations of human psychology. If this be so, we must find some way of modifying the instinctive actions of human beings if we are to prevent the continuing recurrence of such cycles. However, reaching the conclusion that we have simply been caught in the sweep of history and are ourselves, all of us, to blame for our present local difficulties, is not my principal purpose this evening. I am concerned with something much larger and, I believe, of much more serious portent. I want to place before you for consideration a thought which goes much deeper than the cause of any single economic depression, regardless of its magnitude and its seeming seriousness.



Keystone-Underwood

THE MECHANIZATION OF THE FARM DID MORE THAN TO SAVE LABOR AND INCREASE PRODUCTIVITY; IT BROUGHT ABRUPT SOCIAL CHANGES TO THE OLDEST OCCUPATION OF MAN

Before doing so, however, I want to point out a strange characteristic of the work of the appliers of science. These people have produced very marvelous changes in human life by using the tools that you scientists placed in their hands. Some of these changes are undoubtedly good and therefore desirable. But accompanying each of these are others which it is more difficult to evaluate.

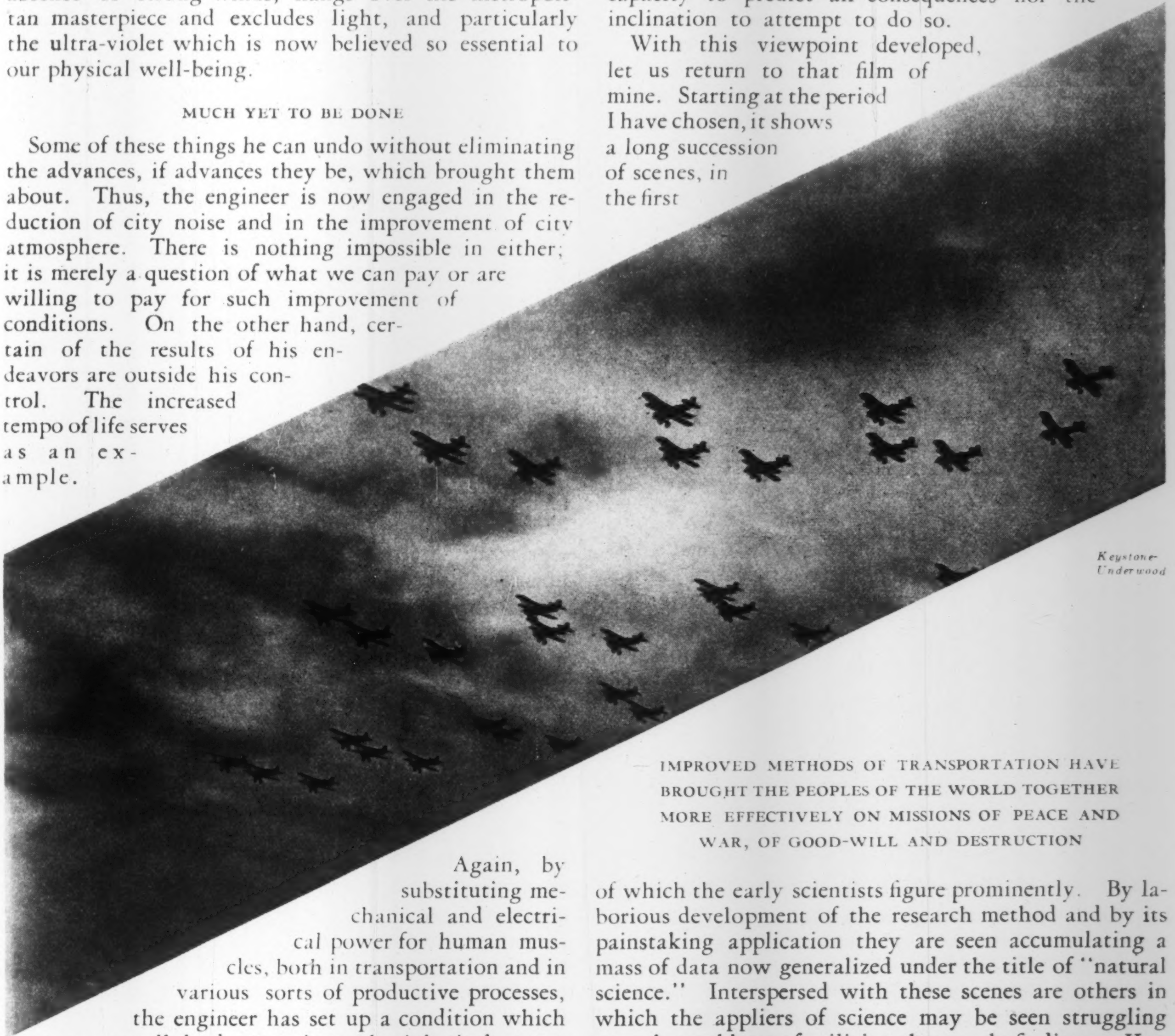
Consider for just a minute one of the things that the doctors of medicine have done in their efforts to better the human lot. They have banished from civilized nations many of the plagues that harassed them and took terrific toll of their numbers in the past. Certainly, in this respect, they have lessened the sufferings of humanity and have thus improved its heritage. But, they have disturbed a natural phenomenon which automatically limited populations. Who shall say what will come out of it? Does it necessarily lead to wars of extermination, with temporary victory to the temporarily most fit?

WHAT THE ENGINEER HAS DONE

Or consider the member of the science-applying group that we designate as the engineer. One of his actuating motives is the use of the scientists' discoveries for the improvement and enrichment of the materialistic sides of human life. He recognizes that, while the Garden of Eden may have been an ideal habitation for the human being, all other sections of the earth have always left very much to be desired. It is his ambition to make life in these other sections as pleasant as he can. He hopes, and believes, that other and better, non-materialistic results will follow as a direct consequence. It is he that devises and constructs your means of transportation, your systems of communication, your multitudinous methods of doing things that you desire to do with less expenditure of muscular effort and with less expenditure of time. He it is who does those things that bring the luxuries of yesterday to the enjoyment of the many. But in doing these things, the engineer, like the doctor of medicine, opened up a veritable Pandora's box. Little did he dream, in his innocence, of the tremendous social and economic forces that he was releasing. It is very obvious, for example, that the modern city could not exist if it were not for the works of the engineer. It is he who provides all the multitudinous services and structures that constitute it physically and upon which its life depends. But in doing these things he has done many others which probably did not even enter his consciousness at the time. He has speeded up the tempo of life to a point at which many serious thinkers begin to question the physical ability of man to endure. He has produced an abominable and nerve-racking jumble of noises which certainly take their toll of the beings who live in their midst. He has produced an atmosphere laden with nuclei of condensation which, in the absence of strong winds, hangs over his metropolitan masterpiece and excludes light, and particularly the ultra-violet which is now believed so essential to our physical well-being.

MUCH YET TO BE DONE

Some of these things he can undo without eliminating the advances, if advances they be, which brought them about. Thus, the engineer is now engaged in the reduction of city noise and in the improvement of city atmosphere. There is nothing impossible in either; it is merely a question of what we can pay or are willing to pay for such improvement of conditions. On the other hand, certain of the results of his endeavors are outside his control. The increased tempo of life serves as an example. Again, by substituting mechanical and electrical power for human muscles, both in transportation and in various sorts of productive processes, the engineer has set up a condition which may well lead to serious physiological consequences. Where we formerly exercised our bodies and preserved a certain degree of physical fitness as a necessary result of our daily activities, things are now so arranged that we conduct these affairs with hardly an appreciable physical effort. What obscure but far-reaching changes may be expected to follow such departures from the conditions under which these bodies of ours were developed?



Keystone-Underwood

IMPROVED METHODS OF TRANSPORTATION HAVE BROUGHT THE PEOPLES OF THE WORLD TOGETHER MORE EFFECTIVELY ON MISSIONS OF PEACE AND WAR, OF GOOD-WILL AND DESTRUCTION

If you will give thought to the activities of all those who apply science to human affairs, you will discover that the twofold character which I have indicated in the work of the doctor of medicine and in the work of the engineer is present in the case of all. As soon as we disturb what may be called a natural order of things—perhaps I should say an inherited order—we produce not only the result that we desire but one or more others which follow as direct consequences. These others may be good or bad. As human beings we have neither the capacity to predict all consequences nor the inclination to attempt to do so.

With this viewpoint developed, let us return to that film of mine. Starting at the period I have chosen, it shows a long succession of scenes, in the first of which the early scientists figure prominently. By laborious development of the research method and by its painstaking application they are seen accumulating a mass of data now generalized under the title of "natural science." Interspersed with these scenes are others in which the appliers of science may be seen struggling over the problems of utilizing these early findings. You see them gradually learn the art of converting new discoveries to practical ends.

As the film unrolls further you ultimately discover the engineer inventing, improving, and applying the steam engine in the eighteenth century, and later harnessing electricity for commercial use. You note the ever-increasing rate of progress. Man becomes more and more powerful as he learns to bend to his purposes the tremendously powerful forces of prodigal Nature, and

Ewing Galloway

THROUGH THE INGENUITY OF MAN, POWER IS NO LONGER THE PREROGATIVE OF FAVORABLY LOCATED COMMUNITIES. ITS CIVILIZING INFLUENCE IS CARRIED TO REMOTE SECTIONS OF THE COUNTRY, AND OVER NATURAL BARRIERS

as he learns to utilize the stores of materials that Nature has placed in the ground, in the waters, and in the atmosphere. The continued use of the research method by scientists and by appliers of science is seen to bring us at an ever-increasing tempo from the early beginnings of power application in England to the hugely mechanized civilization that we know today.

NEW SOCIAL PROBLEMS ARISING FROM NEW APPLICATIONS OF SCIENCE

If you look carefully at the film you will discover that each new application of science ultimately brings in new problems of political, social, and economic characters; new puzzles in government and in human relations, new questions in international relations, new problems with respect to health and well-being of individuals and of populations, new financial requirements, new sorts of crimes, and so on through an endless list. These have been the by-products of our work and have often developed into things of even greater importance than our primary products.

You of the laboratory know that it only requires sufficient skill and perseverance to solve what appear to be the most difficult problems in connection with any one of the commonly recognized natural sciences. We of the applied-science group recognize also that our problems in the physical application of the principles deduced by you are readily solvable by the research route. But, many of the problems that have confronted man along the road he has traveled in the application of science to life have been quite different in character. It is difficult to describe in a few words this difference. The best that I can now do is to say that they always involve people in large groups. I do not mean individual mobs which can be isolated at any instant of time. I mean large sections of populations or entire populations as they pursue their daily lives. They are the problems that we group as political, social, and economic. Let us consider some of them for a moment. The consideration will show how clearly they differentiate themselves from the others. For example, the relations of capital and labor, old as they are, take on new significance and new complexions in our industrial era.

RESEARCH METHODS YET TO BE TRIED

Thus far we have not employed the research method to any measurable extent in the solution of this problem. Through successive generations we have come closer and closer to what seem to be more satisfactory solutions by some sort of blind groping and some sort of instinctive realization of other and better possibilities. We have come to recognize more clearly certain rights of the individual for development and enjoyment. We have succeeded in setting up a form of industrial society which, so long as it remains in working order, enables the worker to obtain both his bare necessities, and some luxuries, with so small a number of hours of toil that he really has time in which to enjoy the luxuries that he has been enabled to earn. We have found a form of ownership of capital goods which enables us to distribute ownership into the hands of the many, so that the laborer and the capitalist are frequently one and the same individual. And, thus far, we have succeeded in doing this without resorting to questionable methods which would substitute idealized desires for the individual initiative and greed which have always characterized humanity and still appear to most satisfactorily function as driving motives.

But, these results have not been the fruits of research as we understand that term. They have been brought about in the gradual evolution of conditions and conceptions that has characterized human progress since the beginning. They represent the product of what one might call social evolution, and progress has been as relatively slow and as lacking in conscious guidance as the term "evolution" would imply.

As another example, take the question of private versus public ownership of such capital goods as are required in the modern social structure. Here is a very broad and very basic question, involving huge masses of people. It is right here with us now as you very well know, and it must be solved. Thus far we have done little more than discuss it and write books about it, except for the rather drastic experiment in Russia.

It is true that we have gropingly and rather blindly developed certain restrictions to the use of privately owned capital goods in ways that are too inimical to the good of others, but the work has been almost entirely restrictive and probably not particularly constructive.

As another example, let us consider international competition in production. Thus far we have made very little progress indeed toward the solution of this problem. We act on the assumption that we have some sort of inherent right to do what we please on a national basis, and we endeavor by means of legalistically created economic barriers to maintain what in many cases appear to be, in fact, false economic positions.

If I read correctly this lengthy film as it has unrolled through the ages, it shows very clearly an almost unbelievably lopsided development. With respect to certain types of affairs, namely, those dealing with the interpretation of natural phenomena and their application, we have broken away from all the older methods and have placed our faith fully in the efficiency and adequacy of the research method. The results are obvious to all. On the other hand, that other huge section of our activities which I have distinguished as involving masses of people is still treated much as it was before we had consciously recognized what we now know as research. In such matters as these we have placed, and continue to place, our trust almost entirely in precedent, tradition, sentiment, mob psychology, "hunch," improvised theory, political expediency—anything at all except proved fact.

If you will look back over my historical film you will recognize the fact that those of us who have had a working knowledge of the research method have, through the ages, been satisfied to go our ways in peace, to confine our attention to our chosen fields, to give the world soul-stirring and precedent-destroying discoveries, and to recognize no responsibilities for the alarming by-products of our works. And now the world faces the consequences. The art of applying science has so far outstripped our other activities that we find ourselves confronted with very real problems indeed. We have learned to produce all sorts of wealth in unbelievable quantities. But we have not learned to adjust the world to such production. All political, social, and economic relations are showing the strains that we have put upon them in building our industrial civilization, and sooner or later they must give way unless greatly modified in structure.

KNOWLEDGE LACKING ON WHICH TO BASE CONSTRUCTIVE MODIFICATIONS

To me the late war in Europe and all that has come out of it represent but a temporary culmination of this idiotic situation: nations groping blindly for some means of balancing production and utilization; nations searching for the secret that will make possible the orderly, plentiful, and full life that we all feel our discoveries should yield; nations realizing the inadequacy of older forms of government, older forms of international agreements, older forms of ownership, older economic concepts. It is shocking to realize that we have no knowledge on which we can base constructive modifications. We try all sorts of economic and political expedients year after year, generation after generation. They operate to appease a temporarily enraged public, or to pacify an estranged neighbor, or to clip, for the time being, the wings of some apparently too powerful minority group. Any one who thinks can see the fallacy of each of these expedients before it is even put into use.

Scientists and appliers of science have brought about a very pretty mess because they were content to do the thing that was comparatively easy, the thing that could be done with research tools of the simplest character.

Keystone-Underwood

THE MODERN CITY IS A TRIUMPH OF SCIENCE AND ENGINEERING. ITS SOCIAL PROBLEMS MUST BE ATTACKED BY THE METHODS OF SCIENTIFIC RESEARCH

And now the world finds itself in need of a complete new tool chest filled with all sorts of new tools not yet even invented. It must have them if it is to find a way of adjusting the politics, the economics, yes, the very life of the world to the thing with which we of natural science have burdened it.

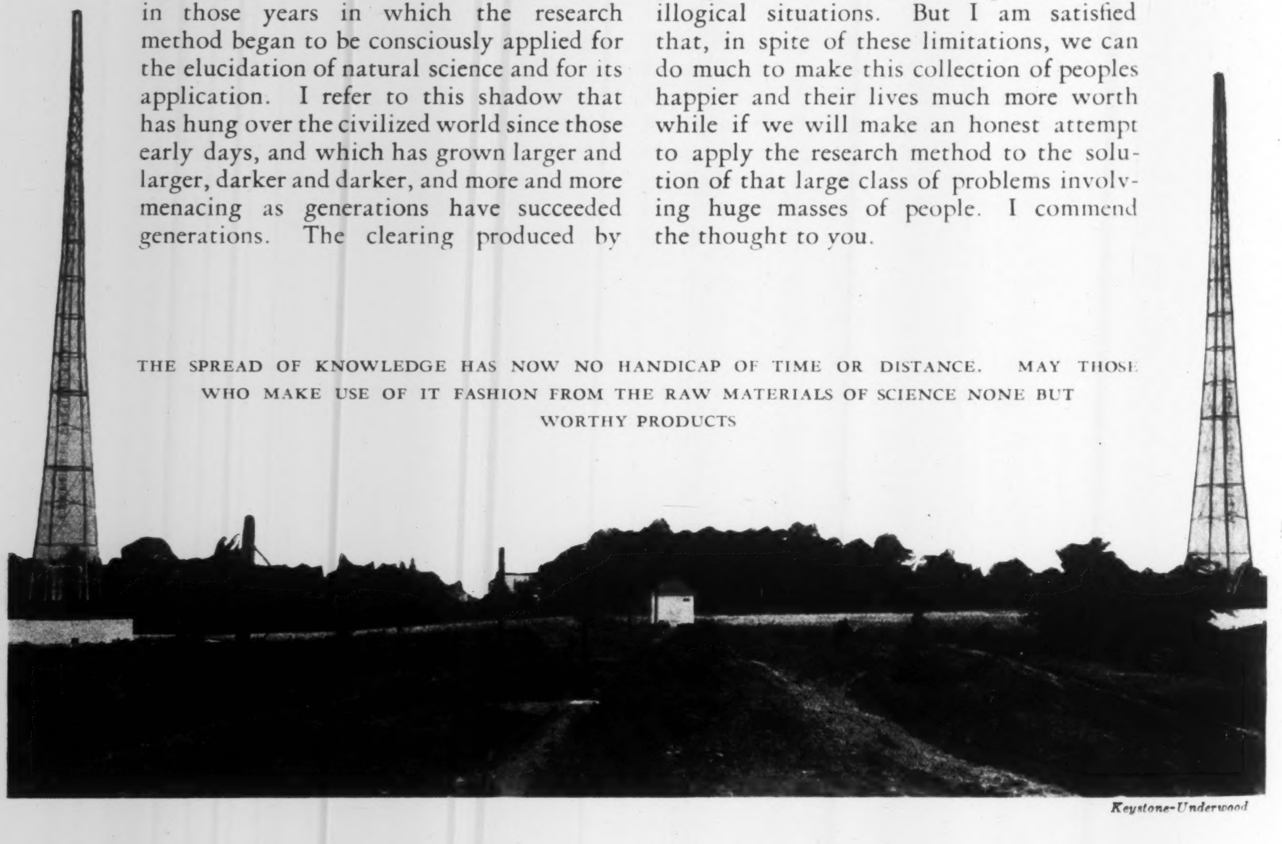
I should hate to believe that we humans are going to find ourselves incapable of devising and using such tools. In fact, I do not believe it. But I am very certain that we shall not do so overnight; I am positive that it is going to take us generations, even in this fast-moving age. And, I am equally certain that until we have done this thing we shall have further upheavals which will represent the payments that we make for being guilty of a most unpardonable mistake. Those of us who are supposed to be possessed of intellects above the ordinary have unconsciously, but very certainly, failed to use common foresight with respect to the results of our labors.

FAILURE OF SCIENTISTS AND ENGINEERS TO FORESEE THE CONSEQUENCES OF THEIR ENDEAVORS

To me, our own present depression, which after all is a very small thing in world history, came about for the immediate reasons that I have outlined to you, but as a small demonstration in a world movement. We, the unbridled and thoughtless speculators, were at fault. But, our own little depression is but part and parcel of a much bigger and more serious situation. I do not refer to the existing world depression, but to the much bigger problem that had its genesis back in those years in which the research method began to be consciously applied for the elucidation of natural science and for its application. I refer to this shadow that has hung over the civilized world since those early days, and which has grown larger and larger, darker and darker, and more and more menacing as generations have succeeded generations. The clearing produced by an occasional thunderstorm such as the late World War has always proved to be only temporary; the cloud returns, always larger, blacker, and more threatening.

I believe I am right in assuming that this cloud is of our own making, and that it will continue to oppress us until we have the sense and the ingenuity and the determination to apply the research method to those larger problems that we unwittingly created and nurtured as we applied that tool to its more simple and more obvious uses. And now, if I may return for a minute to the title under which I address you this evening, I believe it hardly necessary for me to tell you that I am convinced that the major ills of the world today and for some time past are due largely to those of us who have advanced science and the application of science, and who have almost criminally refused to give serious thought to the collateral results. To my mind it is our fault that a civilization capable of producing a surplus of foodstuffs, of material goods required for living, and even of luxuries, a civilization capable of yielding surplus earnings and leisure time to all who are willing to work, finds itself beset by all sorts of little-understood economic upheavals, wars, and social rebellions.

Understand, I do not believe in Utopia. Human beings are undoubtedly going to remain for some time much the same sort of thing that they are now. They are going to continue to see personal advantage, even though they recognize social obligation. They are going to continue to develop misunderstandings and illogical situations. But I am satisfied that, in spite of these limitations, we can do much to make this collection of peoples happier and their lives much more worth while if we will make an honest attempt to apply the research method to the solution of that large class of problems involving huge masses of people. I commend the thought to you.



THE SPREAD OF KNOWLEDGE HAS NOW NO HANDICAP OF TIME OR DISTANCE. MAY THOSE WHO MAKE USE OF IT FASHION FROM THE RAW MATERIALS OF SCIENCE NONE BUT WORTHY PRODUCTS

Keystone-Underwood

The MACHINERY INDUSTRY *During* DEPRESSION

Some Observations Concerning a Faulty Economic Situation

By W. H. RASTALL[1]

WHEN depression comes it is particularly severe upon manufacturers of machinery. A certain economic law is involved, an explanation of which may be found in what follows.

For example, had you been in the machine-tool business in 1919, by 1921 you would have found that 13.6 per cent of the establishments had gone out of business, that 59.9 per cent of the wage earners had lost their jobs, that those who had retained their positions had suffered a loss in wages, for these had declined 61.8 per cent, and the value added by manufacture, the thing that management and stockholders are most interested in, had declined 71.5 per cent. These figures clearly reveal a situation that would tax the resourcefulness of the most capable management. Unfortunately, parallel information is not yet available covering the 1929–1931 experience, but undoubtedly it will prove to be more severe, because, as shown by a chart widely distributed by the Cleveland Trust Company, 1919 was a year in which business activity was slightly below normal for the first six months, and slightly above for the last six, that is to say, half boom, half depression, and a normal year as contrasted with the boom conditions of 1929. So when data are available that will enable us to measure the changes between the peak of the boom of 1929 and the depth of the depression of 1930–1931, it will probably show a much wider span, and consequently—presumably—a more difficult condition.

On the other hand, if instead of being in the machine-tool business in those earlier years you had been in the baking-powder business, you would have found that though 30.3 per cent of the establishments disappeared, the number of wage earners actually increased 6 per cent, wages increased 26 per cent, apparently many employees were promoted, and the value added by manufacture increased 44 per cent, giving management what it wanted. These returns suggest that on becoming engineers, instead of going into the machine-tool business we should go into the baking-powder business! A study of many similar examples indicated in Table 1 enables us to conclude that the business cycle is peculiarly severe on the equipment industries and far more friendly to enterprises manufacturing or distributing "consumer goods." The table shows the experience of the average of all industries as developed from census returns, and it will be observed that as a general rule, using the industries there selected, the equipment industries have done worse than average and the consumer-goods industries better than average. Altogether there are over 300 census industries, and while the table does not pretend to be complete, sufficient examples are presented to illustrate the principle under consideration, and, it is felt, without distortion.

FLUCTUATION OF MACHINE-TOOL ORDERS COMPARED WITH INDUSTRIAL PRODUCTION

The foregoing conclusion can be reached in an entirely different way. In Fig. 1 an effort has been made to show the general business cycle, for which purpose Federal Reserve Board figures of industrial production unadjusted have been used, being drawn to a scale such that the average for eleven years is 100, and resulting in the dotted line there presented. Over this, and drawn to the same scale, is a line representing new orders for machine tools as developed by the National Machine Tool Builders' Association. It will be observed that industrial production as a whole rarely deviates more than 20 per cent from the inclined median line drawn through it. The fluctuations in machine-tool orders, however, are far more violent. In 1919 and 1920, for example, when industrial production increased, say, 20 per cent, machine-tool orders rose to, say, the 300 per cent level, then when toward the end of 1919 prosperity turned to depression, orders decreased so rapidly that in fifteen months they were at a level of only 8 per cent of the preceding peak. Clearly the business cycle is peculiarly severe on the machine-tool industry.

This chart was originally prepared in connection with a discussion of stabilization for industry, and it will be observed that after these two lines crossed on the way down in 1920, and although there was very substantial business recovery in 1923 and again in 1925, they did not meet again for five years, and even then did not stay crossed—the machine-tool curve drooping

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Abstract of remarks made at an economic conference held under the auspices of Stevens Institute of Technology and Columbia University, at Stevens Engineering Camp, Johnsonburg, N. J., August 31, 1931.

and not again rising above the level of general industrial activity until seven years had elapsed. Consequently, when thinking of stabilization as applied to the machine-tool industry we are thinking of the shaded area in the diagram involving a period of seven years, which is obviously so severe as to be beyond the control of management. Moreover, after the machine-tool line crossed that of industrial production at the end of 1927, machine-tool buyers indulged in another orgy. The industry had a violent boom and then collapsed much as in 1919, an experience again suggesting that certain basic economic forces are at work, forces that should have the recognition of machinery manufacturers.

TABLE 1 EXPERIENCES OF SELECTED INDUSTRIES IN 1921 COMPARED WITH THOSE IN 1919

(Increases and decreases expressed as percentages)

	No. of establishments	No. of wage earners	Wages paid	Cost of material	Value of products	Value added by manufacture
Matches	+ 4.5	+22	+40	−83.7	+64	+46
Baking powder, yeast, and other leavening compounds	−30.3	+ 6	+26	− 7.5	+14	+44
Candles	+ 5	+12	+34	+ 1	+12	+43
Wood preserving	+ 7	+ 4.5	+ 4	+47	+43	+30
Refrigerators	− 5	....	+25	+37	+26	+18
Envelopes	+16	− 2.3	+23	+ 9.5	+10.6	+12
Cement	+ 1.6	+ 2.8	+ 5.7	+28.7	+16.2	+ 5.8
Hats, straw	−25.5	−19	− 0.2	−14	−11	− 7.5
Boots and shoes, other than rubber	− 3.9	−13.1	− 2.7	−33.1	−24.9	−11.5
Ice, manufactured	− 5.3	−20.4	− 4.0	+19.4	+16.0	+14.4
Soap	−18.7	−19	−11.1	−37	−24.2	+14.9
Typewriters and parts	−15	−14.6	−15.4	−33.3	−20.8	−15.2
Cigars and cigarettes	−58.7	− 3.5	− 2.5	+28	+ 4	−15.5
Gas machines, gas meters, and water and other liquid meters	−38	−23	−13	−15	−17	−17.5
Washing machines, wringers, driers, and ironing machines for household use	− 8.5	−30	−22	−28.5	−26	−22
Average for all industries	− 8.5	−23	−22	−32	−30	−26.4
Chewing gum	−19.5	−37.5	−20	−21	−24	−27.3
Trunks, suitcases, and bags	−15.5	−24	−17.5	−27	−27	−26.2
Textile machinery and supplies	− 2.5	− 2.5	+ 6.3	− 1.6	+ 5.6	+ 9.9
Electrical machinery, apparatus, and supplies	− 5.1	−24.1	−18.5	−19.1	−16.4	−14.5
Pumps and pumping equipment, not including power pumps	−32.5	−31.5	−41	−33	−28	−24.5
Foundry and machine-shop products not elsewhere classified	−17.5	−33.5	−32.7	−31	−31.5	−31
Windmills and windmill towers	−22.5	−28.5	−26	−30.5	−34	−38
Sewing machines, cases, and attachments	−20	−35	−48	−38	−38.5	−38.5
Saws	−29.5	−31	−35	−44.5	−42	−40
Scales and balances	−17.5	−30	−32	−32.3	−23.5	−46
Foundry supplies	−34	−40.5	−34	−51	−50	−48.7
Belting, leather	− 4.5	−18	−13	−53.7	−52.6	−50.5
Agricultural implements	−32	−44	−40.3	−39.5	−46.5	−52
Tools	−36	−45.5	−48.5	−44	−50.5	−54.3
Files	−22	−37.5	−39	−45	−56.5	−60
Engines, turbines, tractors, and water wheels	−20	−54.2	−50.7	−48.7	−57.1	−64.5
Emery wheels and other abrasive and polishing appliances	−11.5	−49	−51	−50.5	−59.5	−66
Machine tools	−13.6	−59.9	−61.8	−59.4	−68.1	−71.5
Carriages, wagons, sleighs, and sleds	−62	−57.3	−51.4	−64.8	−64.1	−63.3

	1919	1921
Electricity generated, million kilowatt-hours	38,921	40,975
Gas sold, million cubic feet	300,000	326,950

The part of the diagram representing the experience of 1930–1931 is somewhat deceptive, because during this period machine-tool manufacturers accepted an unusually large volume of foreign business. Were this curve corrected to reflect merely domestic trade, the depths reached during the depression of 1931 would be very much lower.

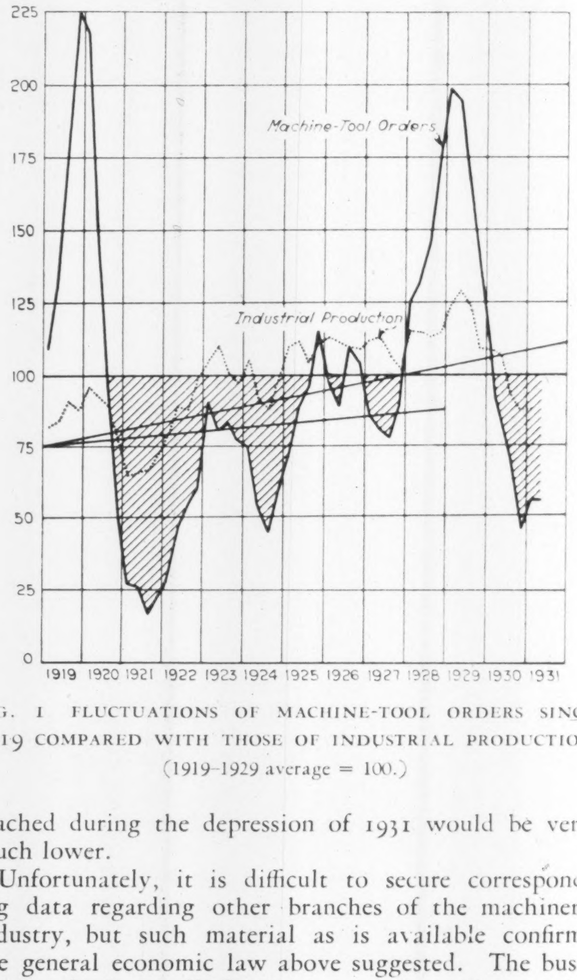


FIG. 1 FLUCTUATIONS OF MACHINE-TOOL ORDERS SINCE 1919 COMPARED WITH THOSE OF INDUSTRIAL PRODUCTION

(1919–1929 average = 100.)

Unfortunately, it is difficult to secure corresponding data regarding other branches of the machinery industry, but such material as is available confirms the general economic law above suggested. The business cycle is peculiarly severe on the equipment industries, in fact, the question has been raised as to whether the ups and downs of these industries do not in large measure account for the ups and downs of the general business cycle. There is reason to believe that to an important extent this is true, and that if it were possible to smooth out the fluctuations in demand in the equipment industries we should at the same time do much in the way of smoothing out the general business cycle. In making this statement it is of course recognized that many other forces are also at work, nevertheless it should be acknowledged that the equipment industries occupy a unique position both in booms and in depressions, a conclusion that has been reached by several well-recognized economists thinking subjectively rather than objectively.

IMPROVED BUYING POLICY A DESIDERATUM

Fig. 1 further appears to suggest the corrective that should be applied to this situation: namely, a better buying policy on the part of those who use industrial equipment. Clearly, during 1919 and 1929 machine-tool buyers indulged in an orgy that was little short of anarchy, while in 1921 and 1931 there was a refusal to buy that might almost be called paralysis. Each extreme betrays the fact that industry has no adequate policy governing the procurement of equipment. It is not the intention here to characterize the equipment industries as particularly hazardous types of business, nor to discourage engineers from going into the production of machinery, but rather to emphasize to those of us who have dedicated our lives to this sort of work the fact that steps should be taken to make these industries more wholesome through a different and better type of sales effort. Recognition of the principles involved would undoubtedly lead machinery manufacturers to discourage reckless buying such as took place in 1919 and 1929. Even as conditions are, the machine-tool industry has an excess of factory capacity, and yet this capacity was overtaxed during those years; shifts worked overtime, some plants worked double shifts or on Sundays and holidays, all of which was costly, and yet it would not seem that prices were then raised either to cover the added costs or in response to that thing economists call the law of supply and demand. It would seem to be necessary that management find a new way of meeting conditions of this type when they occur, for the resulting situation is not to the advantage of the machinery buyer or the public generally, entirely apart from its effect on the machinery manufacturer. At the other extreme it would appear that steps should be taken to encourage an adequate replacement policy when conditions are as they were in 1921 and 1931. At such times, entirely apart from any price advantage that might exist, industry is in a position to replace machinery without seriously interfering with its manufacturing operations. Purchases made at such times reach machinery manufacturers at a season when they are in a position to give their best in the way of workmanship, deliveries, and service. All of which represents an important dollar value in the capital accounts of the industries concerned. This is a policy that is actually followed to some extent in the steel industry, for it is to be noted that that group of enterprises spent huge sums on plant rehabilitation in 1930–1931, a policy that greatly strengthened their equipment manufacturers. It is of course recognized that many practical difficulties arise when efforts are made to apply these policies generally, notwithstanding which the need seems to be urgent, and an opportunity for constructive work is definitely at hand.

PROBLEMS FACED BY MANAGEMENT IN MACHINE-BUILDING ESTABLISHMENTS

This curve showing the ups and downs of machine-tool orders also suggests many other problems faced by management in establishments producing machinery. For example, probably 40 per cent of the value of the product is represented by overhead costs, but it makes a great deal of difference what basis is used for calculating these items. If management in a given establishment calculated its overhead on the basis of volume of business secured in 1919 or 1929, it would not find overhead costs covered in years like 1921 and 1930. At the other extreme, were management conservative and arranged its price structure so as to cover overhead items in these latter years, it would undoubtedly find its prices out of line with competition, overhead being exaggerated. In fact, instead of establishing a price structure where overhead costs are arrived at on the basis of the experience of a single year, it is probably necessary to consider the experience of the entire decade. A careful study of this problem was made by E. F. DuBrul of the National Machine Tool Builders' Association, and his curve and conclusions were presented in *The Iron Age* of May 29, 1930, at which time he indicated that in the machine-tool industry, management probably would not be able to cover overhead costs over a decade if these were taken into the price structure at a level higher than 65 per cent of one-shift capacity. In greater or less degree it would appear that this also applies to other branches of machinery manufacture.

Similarly, in these days of scientific selling and management there is a disposition to develop quotas for sales, for production, and what not. Presumably the object of a sales quota is to stimulate the morale of the individual salesman, giving him an opportunity to better his individual position as the result of his own effort. Mr. DuBrul's curve seems to indicate that any such quotas must be adjusted from year to year, and to be effective for the purposes for which it was designed must be adjusted to meet the fluctuations of the business cycle; and although the stock market appears never to have been able to forecast these fluctuations, nevertheless it seems necessary for management in machinery industries to adjust sales quotas, forecasting with great care changes in the business cycle in order that the sales quotas may actually mean to the salesmen what they were originally designed to cover. Obviously, this is exceedingly difficult, yet very necessary, and applies not merely to sales quotas but to manufacturing quotas, in fact, to operations generally.

More and more there is a tendency in industry to employ management ratios. In the machinery industry, for example, capital should be turned over, say, once a year. The ratio of sales to assets, sales to merchandise, cash to total liabilities, etc., etc., should all be watched very closely. These ratios and many others should constantly be applied in order that the activities of the enterprise be kept closely within the limitations required by good management. It will be found, however, that such ratios will also change greatly from year to year

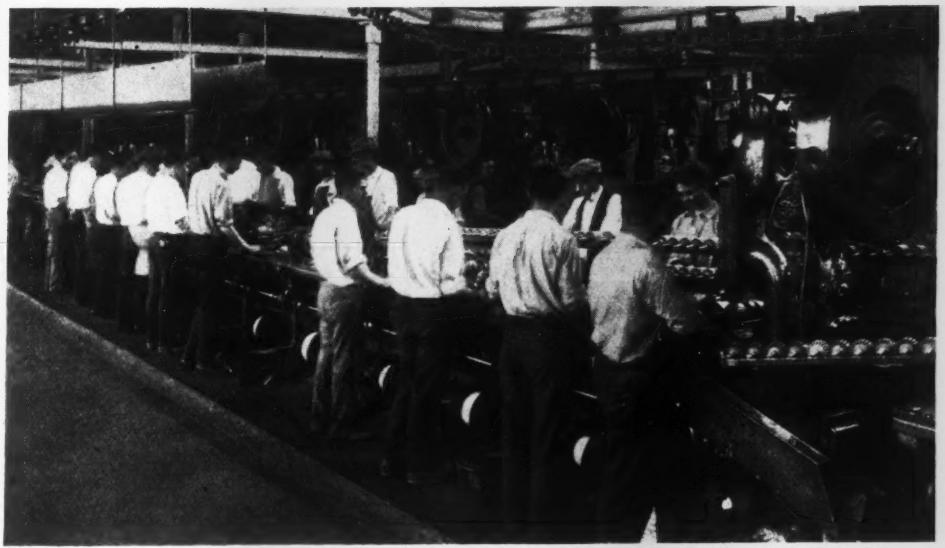
TABLE 2 NET EARNINGS OF MACHINERY MANUFACTURERS AFTER DEPRECIATION AND TAXES

Firm No.	1928	1929	1930
1	$4,128,273	$3,543,140	$1,849,464
2	......	530,000	78,000
3	......	219,000	69,000
4	1,428,161	2,645,000	2,931,000
5	2,055,080	2,546,530	2,067,740
6	570,781	546,256	211,000
7	1,412,079	993,086	241,630 (*d*)
8	......	79,000	24,000 (*d*)
9	......	1,044,000	199,000 (*p*)
10	......	3,302,000	2,439,000
11	......	(11 mos.) 204,000	42,000
12	......	204,000	676,000
13	1,108,310	2,098,000	71,000 (*a*)
14	......	102,000	80,000
15	1,272,104	1,582,161	207,317
16	80,008	150,198	216,052 (*d*)
17	......	626,000	500,000 (*d*)
18	......	845,000	515,000
19	......	266,000	177,000
20	......	1,023,000	845,000
21	......	143,000	66,000
22	......	716,000	51,000 (*d*)
23	130,115	201,057	22,913
24	......	1,297,000	900,000
25	......	4,000	479,000 (*d*)
26	......	2,113,000	248,000
27	......	1,130,000	327,000
28	2,161,671	2,348,671	821,612
29	625,075	772,300	472,548
30	......	407,000	27,000
31	......	613,000	1,840,000 (*d*)
32	......	1,617,000	1,651,000
33	......	615,000	251,000
34	456,852	598,829	138,567
35	......	1,490,000	652,000
36	......	340,000 (*d*)	247,000 (*d*)
37	......	868,000	449,000
38	......	126,000	98,000 (*d*)
39	......	1,241,000	66,000
40	8,017,186	10,654,000	7,000,000 (*e*)
41	53,183	359,124	135,595
42	1,040,689	1,332,000	589,000
43	......	1,926,000	2,000,000
44	......	528,000	257,000
45	......	347,000	37,000
46	......	134,000	41,000 (*d*)
47	......	274,000	96,000
48	......	451,000	51,000
49	3,241,823	3,484,686	2,310,332
50	......	197,000	205,000
51	......	280,000	172,000
52	607,734	1,309,422	443,981
53	1,392,995	1,446,874	761,571
54	......	2,101,000	9,000
55	......	461,000	34,000 (*d*)
56	......	611,000	89,000 (*d*)
57	......	161,000	274,000
58	......	534,000	685,000 (*d*)
59	......	383,000	268,000 (*d*)
60	......	1,797,000	2,509,000
61	......	2,707,000	922,000
62	......	465,000	133,000 (*d*)
63	......	1,275,000	1,083,000
64	7,343,895	8,670,528	7,265,000
65	......	185,000	391,000
66	44,000	......	142,000
67	......	37,000	29,000 (*d*)
68	892,861 (*d*)	1,004,054	890,340 (*d*)
69	958,797	1,289,232	295,380 (*d*)
70	83,798	117,218	81,986 (*d*)
71	520,976	504,160	90,671
72	......	333,000	31,000 (*d*)
73	......	308,000 (*d*)	199,000 (*d*)

(*a*) Before certain charges.
(*d*) Deficit.
(*e*) Estimated.
(*p*) Preliminary.

in the equipment industries, because of the severity with which the business cycle impinges on these trades, and management is faced with a very delicate problem when it undertakes to protect the interests of the stockholders in the face of so complicated a situation. Perhaps this is why so many machinery-manufacturing firms have disappeared. The mortality experience over a series of years is quite discouraging, in spite of the fact that the machinery industry is not only more than a key industry, more than a basic industry, but is the one industry upon which all of our other enterprises depend for their equipment and for their progress. It would appear that it is necessary to raise the standard of management, positively and definitely.

This contention is proved by the profit experience of the machinery industry. According to census returns there are 10,000 firms in the country producing industrial machinery. So far as can be learned there is not a single one whose securities are rated better than "A." From this one might gather the impression that the stock market does not look kindly upon the shares of machinery manufacturers, and it will be observed in Table 1 that, while the equipment industries in 1921 found themselves in a very bad position as compared with 1919, the utilities enjoyed a much more favorable and highly contrasting position. Kilowatt-hours produced went up from 38,921,000,000 to 40,975,000,000; cubic feet of gas sold went up from 300,000,000,000 to nearly 327,000,000,000. Parenthetically, it is interesting to note what happened to the industry producing "carriages, wagons, sleighs and sleds;" it is the author's impression that this particular trade was all but obsolete in 1919, consequently, when depression came in 1921, 62 per cent of the establishments closed, 57.3 per cent of the wage earners lost their jobs, and value added by manufacture fell off 63.3 per cent. Is it not remarkable that this showing is more favorable than that of the machine-tool group which is so highly important to the welfare of industry generally? Such considerations have led to a study of the profit experience of as many machinery-manufacturing establishments as possible. Some of the data obtained are confidential, which makes it necessary to omit the names of the companies, but substituting numbers for names, the returns are as indicated in Table 2, which is self-explanatory, for profits fell off most seriously in 1930 as compared with 1929 and a long string of deficits accumulated; and yet even these figures perhaps include some "enlightened bookkeeping," for it simply is not human nature for management to put out statements that are not as optimistic as possible. It is true there are exceptional firms that show increased profits. In some instances these reflect earnings from patents of exceptional merit. In other instances increased profits are reflected by firms that make equipment for the steel industry, which, as stated, rehabilitates during a depression with advantage to all concerned. Apart from such instances, though, this table showing profit experience is a most emphatic argument that the machinery industry needs to take steps to improve the policies under which it has operated.



Photos in this article by Ewing Galloway

INDUSTRIAL EFFICIENCY *and* ECONOMIC EQUILIBRIUM

By R. H. McCARTHY[1]

INITIAL responsibility for one of the vast array of social and economic difficulties that beset us rests largely upon engineers and their associates. That is the responsibility for serious disturbances caused by distinct efficiency gains in all phases of industrial activity. During prosperity the engineer who hesitated to increase the efficiency of labor, management, or capital would be accused of emotional instead of logical thinking, yet in depression when inefficient instead of efficient methods are deliberately employed in order to give more work, we wonder if the thinking during prosperity was complete. How many engineers have spent any time in restoring the economic balances thrown out of equilibrium by their developments? This, they say, is not their function nor within their power in our highly specialized social organization, and, for that matter, new balances are gained by natural processes. This is, in part, correct. They are gained by such natural processes as the current depression in which engineers suffer along with the rest.

We must acknowledge that the quest for efficiency is with us, and that nothing short of social and educational upheavals will halt it. Hence persistent analysis and discussion of this tool of industry are necessary if we are not to be overcome by its blessings.

The purpose of the following is to analyze the significance of industrial-efficiency measures and to discuss the desirability of letting these measures reward industry's immediate dependents in the form of higher wages or lower hours, rather than the general consuming market in the form of lower prices.

LABOR EFFICIENCY

Engineers and industrial leaders are familiar with increases of manual efficiency amounting to 15 per cent and frequently more in practically every industry, including the age-old trades of masonry, carpentry, and porterage. Increases of this magnitude may result from wage-incentive systems even without changes of tools or machinery. A 15 per cent efficiency increase presents many possibilities, such as 15 per cent fewer workers, 15 per cent greater production, lower sales prices, greater profits. Any one of these is enough to create a sensible economic unbalance.

The engineering approach to labor efficiency is impersonal. By means of observation and analysis a fair daily output is established, which can be met day after day, year in and year out. It is assumed that no worker can reasonably object to producing as much as possible consistent with maintained bodily, mental, and spiritual vigor. But having set a task, the engineer steps out of the picture, leaving society as a whole operating through demand and supply in the local labor market to establish

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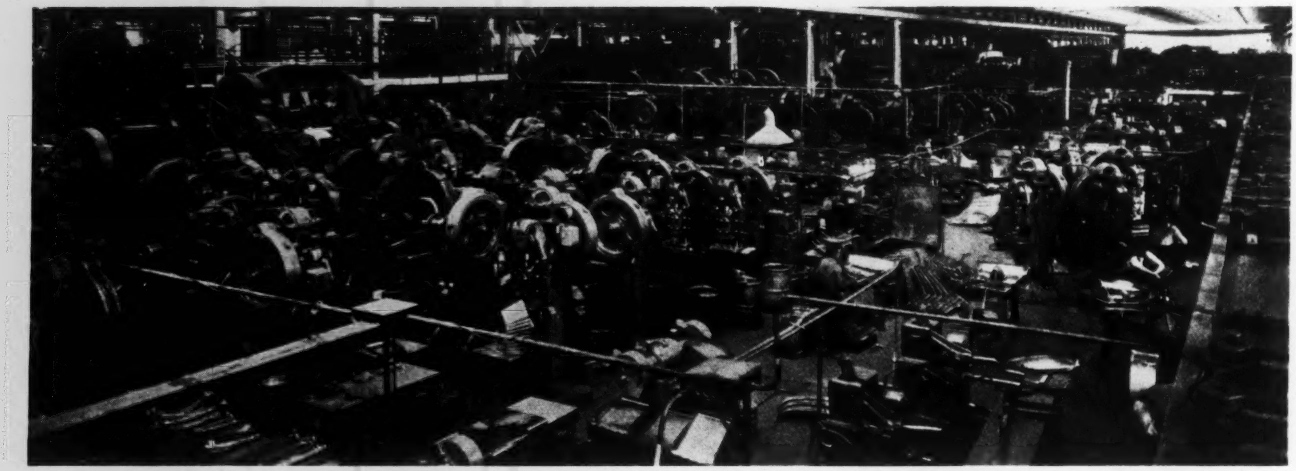
[1] Flushing, L. I., N. Y. Assoc-Mem. A.S.M.E.



the worker's wage. The engineer has little to say, and may have little interest in what becomes of the saving due to decreased labor. Enlightened management and ownership will dispose of some of the saving by raising the pay of this more efficient labor above the market level, and can well afford to do so because the economy of efficient labor is the result of more than the direct labor-cost saving. The remainder, which is usually the major portion of the saving, goes the way of all operating profits, into greater dividends, reserves, plants, and lower prices.

MANAGEMENT EFFICIENCY

Management provides many devices for increasing efficiency. Such is the purpose of bookkeeping machines, sales, production, and inventory control charts, objective quality standards, compiled managerial instructions, scientific forecasting, budgetary control, supervisory training courses, professional and trade magazines, mergers, and—in the same breath—decentralizations. The goal is to eliminate unnecessary work and to organize so that more work can be done by the unskilled, turning the reduced number of skilled employees into intellectual distributing centers freed from purely routine work.

Although it is common to hear of workers in the managerial class being out of work because of merger efficiencies, probably the greatest result of management efficiency has been to reduce direct labor, even at the expense of increasing ratios of non-productive to productive labor. The net result again is to reduce the cost of production, creating a surplus that upsets economic balance at some point. Very seldom do the people (other than the owners) directly dependent upon specific enterprises share tangibly in these surpluses. When a new balance is established, it is by increased sales due to lower prices passed on to the consuming market, or by the creation of more productive capacity.

CAPITAL EFFICIENCY

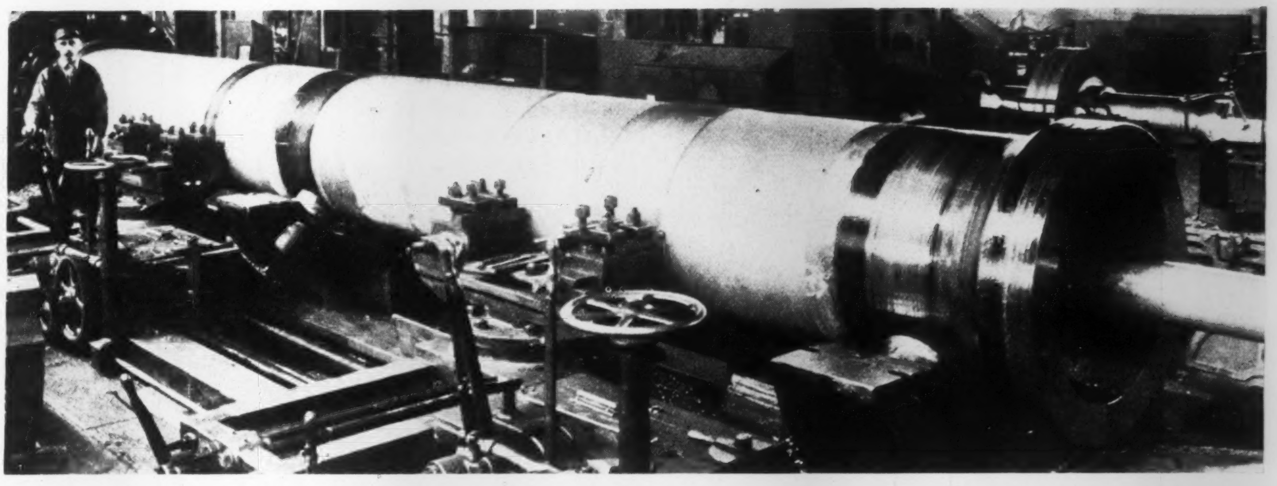
The efficiency of capital is measured by the return on investments that provide and control credit, industrial grounds and buildings, machinery and tools, and funds to pay labor, and management in advance of the sale of goods. One of the purposes for which capital is commonly used is the purchase and introduction of labor-saving equipment. Few people today would discredit the motive of ownership which for $3000 purchases a power-driven machine that will replace three laborers each earning $1000 annually, for, as we say, the machine will pay for itself in one year. But this typical use of capital, repeated thousands of times, continually upsets the balance of social and economic forces by making capital a progressively larger force and labor a progressively smaller one, a fact demonstrated in part by the increase of prime-mover horsepower per worker from 32.6 in 1919 to 46.5 in 1927.

To assume that the labor required to manufacture a machine completely compensates for the labor it displaces when it goes into use, belittles the judgment of industry as a whole and contradicts the essential facts. Obviously machinery is installed to reduce costs and increase profits. On the face of it, a machine that will pay for itself in labor costs in a given time required much less than that amount of labor to build it. The only hope that the introduction of machinery holds out toward creating a demand for labor is based upon greater sales due to lower prices.

That labor-saving equipment does what it is designed to do there is no serious doubt, nor do many engineers doubt that the conservation of labor is ethically for the best. Outside the profession, however, this confidence is not unanimous. Germany is deliberately experimenting in Saxony with a reversion to crude construction methods to spread the available work over a larger number of people. The Bishop of Ripon has urged that scientists take a vacation of several years.

INDUSTRIAL EFFICIENCY IN THE BUSINESS CYCLE

Prosperity. During the upward swing toward prosperity, society does not concern itself with the disposition of gains resulting from increased labor, management, and capital efficiencies. An apparently insatiable demand, stimulated by all the arts of modern high-pressure salesmanship, maintains prices, increases wages and employ-



ment somewhat, and profits and plant capacity considerably. The other outlets for efficiency gains, i.e., lower prices and decreased employment, are temporarily blocked. No one complains seriously, because every one is relatively better off than ever before.

The conventional supposition with respect to a competitive industrial system is that disturbances from efficiency gains are adjusted by price reductions with resulting greater sales. But in the face of a situation that can conservatively be estimated as having raised the efficiency of all industrial productive factors by ten per cent, prices held practically constant over the eight-year period from 1921 to 1929. Apparently price reduction was delayed, indicating that prices were not in stable equilibrium, that production and sales rested on a false foundation (a widening margin between costs and prices), and that sooner or later competition would undermine that foundation.

A picture of the unbalanced forces is evident in the following data taken from the Federal Reserve Bulletin, based on the average of 1923–1925 as 100 per cent.

	Depression 1921	Prosperity 1929	Depression 1930
Total production of manufacturers	67	119	96
Workers employed	82	101	88
Workers' income or total payroll	77	108	87
Commodity prices	98	97	86

An analysis of these data gives the following results:

	1921–1929	1929–1930
Total production of manufacturers	77% gain	19% loss
Workers employed	23% gain	13% loss
Workers' income or total payroll	40% gain	19% loss
Commodity prices	1% loss	11% loss

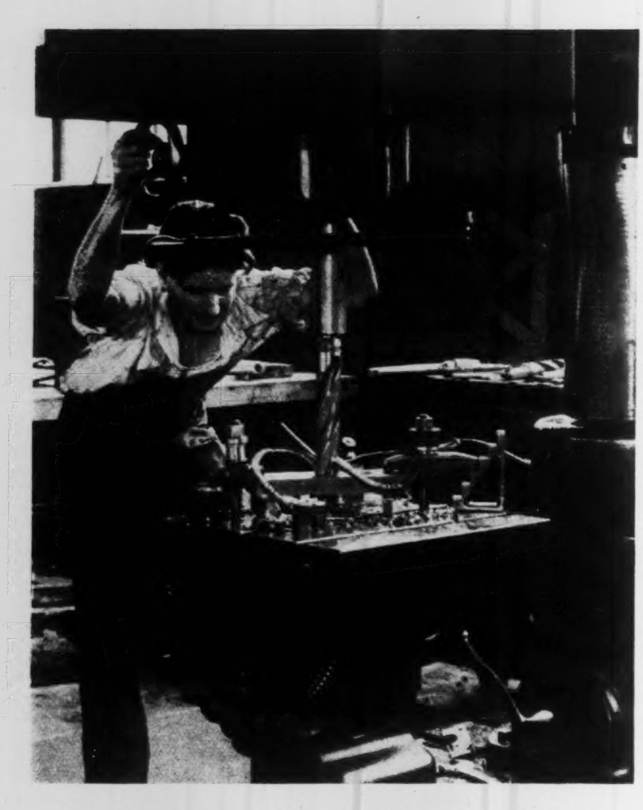
Depression. These data reveal certain forerunners of depression: a production gain over three times as great as the gain in the number of employees; a payroll gain amounting to only one-half of the sales gain; a constant commodity price in the face of very evident efficiency increases. The data for the period 1921 to 1929 show the growth of an unstable economic equilibrium which was highly susceptible to a forced liquidation. That liquidation consisted of deflated cost-price margins and of reduced sales, employment, and wages, phenomena which are now painfully familiar.

Industrial efficiency, as engineers well know, has been one of the most disturbing factors leading to the unstable equilibrium. The question then arises, how may efficiency gains be liquidated currently to prevent the disastrous piling up of unbalanced forces? Let it be understood that what follows is not intended to be a cure-all for depression. It is an attempt to discover a rational way of escaping this particular horn of the dilemma.

CURRENT LIQUIDATION OF EFFICIENCY GAINS

It is obvious that manufactured goods must have a profitable market if their production is to be on a continuous basis. It is also evident that about one-third of the total demand for consumption goods is made by gainfully employed workers, and is therefore directly proportional to the wages of the 14,300,000 workers in manufacturing and mechanical industries who control the expenditures of about 36,000,000 ultimate consumers. (Foreign trade does not affect this line of reasoning because in the long run our purchases must equal our exports, which is another way of buying our own goods.) Assuming the average annual wage to be the moderate amount of $900 per worker, the annual purchasing power of about $12,000,000,000 of these ultimate consumers is more important in its effect on industry than the capital purchases for manufacturing equipment. From the standpoint of national economy and return on investments, therefore, it is more desirable to maintain the purchasing power of the ultimate consumer than that of plant reserves.

If the foregoing Federal Reserve data are reliable, a sharp increase of industrial efficiency has occurred, but the purchasing power of ultimate consumers has failed markedly to keep step with the associated increased production. If wages did not increase in proportion to the increased sales, it is because of other and larger outlets than wages for the rewards of increased efficiency. No mystery hides these other outlets during times of pros-



perity. They were profits distributed as dividends or laid aside for future plant expansion. In either case a long interval elapsed between the time when the profits were earned and when they appeared in the hands of ultimate consumers—excluding as ultimate consumers those who spent for tools, machinery, and buildings intended to manufacture more goods.

But during depression the outlet for the rewards of efficiency gains is to decrease commodity prices to the general market. This can be done because efficiency changes have lowered manufacturing costs, and is done because every merchant has an idea that sales can be maintained if prices but go down far enough. Both the outlets of prosperity and those of depression leave the individual laborer relatively and absolutely a loser.

In prosperity the lagging wage increases do not permit sharing fully in the increasing volume of goods. In depression some workers must lose employment. True the individual laborer displaced by efficiency is somewhat compensated eventually by the general reduction of prices, but price reductions to consumers as a whole do not automatically and immediately enable the unfortunate individuals out of work either to live on nothing or to get another job.

PROBLEM OF THE DISPLACED WORKER IN DEPRESSION

An example taken from the experience of a woodworking plant employing less than 400 men will make the problem of the displaced worker in depression specific. The engineers found that specialization of effort, the introduction of piece rates, and a small amount of machinery reduced the labor required 40 per cent. Of the 100 cabinet makers formerly in the department, 40 were no longer required. These 40 men were released to find work elsewhere and the pay of those who remained was increased as much as 25 per cent, leaving the remainder of the saving to be distributed between ownership as increased profits and the general furniture-consuming market as reduced prices. From the social standpoint this solution of the problem was extremely incomplete. The 40 men must eventually compete in the labor market with the 60 who remained, and thereby reduce wages to a figure lower than ever if this condition is general in all industries.

The 40 men are problems, for it is foolish to assume, if the history of the 1921–1930 period means anything, that they have but to go around the corner to find other work. In the first place, some of that work is no longer to be had. In the second place, years of specialization as cabinet makers, ownership of real estate, education of children, family tradition, old age, attachment to environment, all resist the easy flow of labor from one job to another. Can a small reduction of price to each of the thousands who make up the furniture-using market be looked upon as an equitable compensation for the difficulties of the 40 men and their families, especially when it is entirely probable that many of the ordinary manufacturing economies entirely disappear before reaching the ultimate consumer because of the many hands through which the product must go, jobbing house, wholesaler, retailer?

The ethics of various dispositions of profits is not a subject for discussion here, except that it may be pointed out that inflated profits are not immediately productive of purchasing power. But when there is an alternative of passing a saving on to the ultimate consumer as against sharing it with employees, it certainly seems as if the prior obligation is to the employees who have done something to earn the reward. Had the furniture manufacturer reduced working hours enough to retain all 100 cabinet makers without changing wages, he still would have made a saving in overhead charges for depreciation, power, heat, etc., and the furniture market would have remained in equilibrium. Likewise the employees would have had a new incentive for efficiency, an incentive behind which lay no threat of unemployment for some of their number. Under such conditions it would be quite within reason to expect from labor enthusiastic support of research and engineering.

A proposal of this kind which shares savings with the productive labor concerned at the expense of either ownership or the consuming market or both, is plainly a form of profit sharing. The approach, however, is somewhat different from the common conception of profit sharing, which frequently carries the suggestion of philanthropy and paternalism. This approach is an attempt to keep price levels, employment, and purchasing power on an even keel at their source by the immediate application of corrective forces, instead of waiting for an extremely complicated economic system to build up corrective forces which eventually carry all before them in one devastating crash.

Some variations of this proposal to retain labor and to maintain prices constant in order to reduce the disturbances of efficiency changes are as follows:

1. The engineers who initiate efficiency increases might appropriately be called upon to design improvements in quality which by their added labor cost would completely offset labor savings
2. Efficiency gains which are not the result of labor saving can be dissipated by wage increases or by reducing working hours and hiring more labor without change of the total wage per person
3. At times engineers have alternative methods of obtaining savings. Of these the one involving the least labor elimination is to be chosen, even though some of the advantages of machinery over labor are lost.

Many objections can be found to proposals of this kind:

1. The employers of a given neighborhood do not like to vary widely in their treatment of employees. It would be embarrassing for an efficient enterprise to operate on a six-hour day while a less efficient neighbor required eight hours
2. If most of the rewards of efficiency go to labor, ownership would have a reduced incentive toward investing the capital essential to some efficiency developments
3. A policy of fixed prices might stifle many of the desirable characteristics of competition.

As stated before, the object in this discussion is not to examine the distribution of profits between labor and ownership. Needless to say, ownership, if it is to remain private instead of governmental, must have some incentive in the form of profits if capital is to be accumulated for new or expanded enterprises. But it has been the object of this discussion to point out that the rewards of efficiency which normally go to the general market as lower prices might better, in the interests of economic equilibrium, go to the management and labor of the enterprise responsible for the efficiency increase.

DIAGNOSES AND RECOMMENDATIONS

Our daily news shows the emergence from rather surprising sources of diagnoses of our economic maladjustments and of recommendations for treatment. From the most conservative of Government officials comes the pronouncement that wages and standards of living must not fall. A national organization quite far removed from organized labor and from socialism, and a high ecclesiastical authority, call for a more even distribution of wealth. An industrial leader points out the disconcerting effects of improved methods in eliminating the need for labor at a time when the policy of his organization is to retain all employees. Many in the ownership class are calling for governmental regulation to prevent the disastrous effects of competition. These ideas are not those of radicals, they are the considered opinions of responsible people, colored doubtless by the despair of depression. They center on the knowledge that there is enough material wealth to "go around" and that the time and effort required to fulfil the material wants are less than ever before, and the belief that those who want to work are entitled to the opportunity. Surely it should be possible to make available the benefits of efficiency gains to society via the individual worker without going through the cataclysmic growing pains we have experienced. Any measure bringing higher efficiency to an industry should first protect the workers of that industry by assuring them a continued livelihood on the same or a higher plane, and, second, it should reward the consuming market with greater purchasing power and constant prices.

The destructive lack of control over the growth and efficiency of industrial power is evident to all who care to think about and listen to the talk of the day. Either labor and management will soon insist that control be placed in governmental agencies, or else a far more enlightened and scientific attitude toward the responsibilities of industry and commerce must be adopted by private enterprise, individual and corporate. This attitude involves a thorough revision of sales-promotion and cost-reduction policies, and, most of all, a change of thought toward competition and toward the bases for the distribution of profits. Society has been adrift on a headlong, uncharted flow of natural resources and productive power. Some of the boundaries originally set for the stream, such as the doctrine of Malthus, the starvation theory of wages, and the insatiability of human wants, are losing control. New limits based on changed social values and a vastly altered power to produce need to be erected if we are to make the most of our power abundantly to satisfy human material wants.

The Basic Laws and Data of
HEAT TRANSMISSION

By W. J. King[1]

AN ENGINEER'S stock in trade consists very largely in his knowledge of the fundamental physical processes and laws governing the utilization of energy in various forms. Heat is a basic form of energy, which invariably appears in all transformations from one form of energy into another. There is almost no form of engineering which does not involve problems in the generation, transmission, or dissipation of heat. It therefore behooves engineers in general to know something about heat, and it is evident on all sides that most engineers do not know nearly enough about this essential part of their professional equipment.

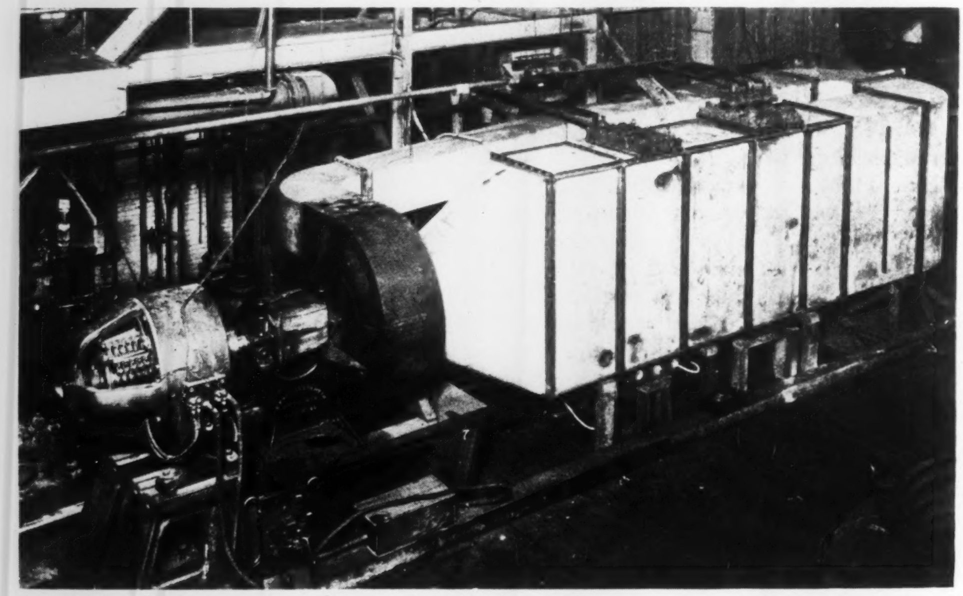
The literature of heat transmission consists of a mass of widely scattered articles on particular aspects of the subject, and these form a rather chaotic and confusing picture. A considerable portion of it is published in foreign languages, particularly the German, which permeates very slowly American engineering practice. Many of the experimental results are unreliable and inconsistent, and it is frequently very difficult for a busy engineer to obtain dependable information in immediately usable form.

The purpose of the present series of articles is therefore to outline what every engineer ought to know about heat transmission, to separate the wheat from the chaff in the voluminous and incoherent literature of the subject, and to present the most significant results in convenient form for general engineering use. This work is based on an intensive study, during the past four years, of all phases of heat transfer, including an exhaustive survey of the literature, a study and development of the theory, a continuous series of experiments in the laboratory, and the practical application of the results to a wide variety of engineering problems. It was originally prepared in the form of lectures to be delivered to classes in the Advanced Course in Engineering conducted by the company with which the author is associated, the purpose of this course being to provide mechanical and electrical engineers with information which is considered essential to their training in connection with the design and application of all types of apparatus.

I—GENERAL SURVEY

Although the manifestations of heat have been studied by engineers and physicists as far back as the beginnings of science, there are two aspects of heat transmission which have hindered the progress of this subject and caused it to lag behind the more highly developed fields of mechanics, electricity, and chemistry. In the first place, heat is very difficult to control and measure. It is almost impossible to keep it within definite channels; it usually leaks in every direction, even with the best insulators available. There are no convenient and accurate heat-flow meters, corresponding to the electrical ammeter, and the greatest care is necessary to obtain accurate temperature measurements. In the second place, it is only in a small degree amenable to mathematical analysis and manipulation, because of the number of variables involved and the uncertainty of the boundary conditions in most problems. As a consequence, physicists and mathematicians have rather neglected the study of heat transfer, although the mathematical analysis of conduction has received considerable attention, and engineers usually resort to empirical data and cut-and-try methods. It is frequently considered more expedient to set up apparatus and run tests to obtain the desired results than to attempt to predetermine them by calculation.

On the other hand, there are two arguments in favor of the theoretical and practical study of general heat-transfer problems. First, in spite of the difficulties, there are many instances in which the application of mathematical analysis yields very interesting and useful results. This is particularly true of the use of dimensional analysis in correlating an incoherent mass of data, enabling new facts to be predicted outside the immediate field of observation. Secondly, any



SURFACE AIR COOLER UNDERGOING TEST

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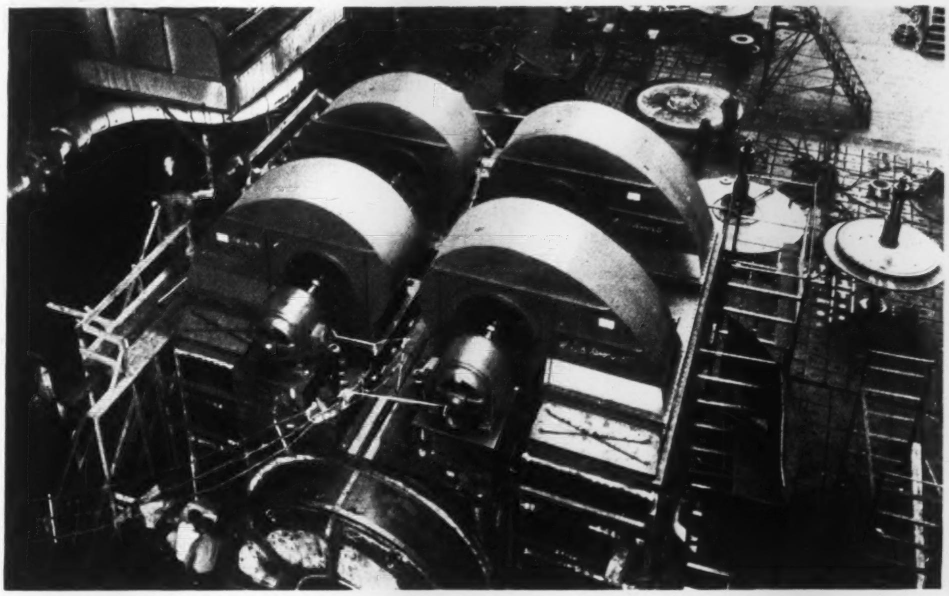
[1] Engineering General Department, General Electric Company, Schenectady, N. Y.



LARGE TURBO-GENERATOR AND ITS COOLING EQUIPMENT
(The compartments located on the sides contain the surface air coolers.)

resort to direct experiment or test usually involves a great deal of delay, expense, and care if trustworthy results are to be obtained. The sources of error in working with thermal apparatus are manifold, and they are sometimes not suspected even after the tests are completed. Almost invariably the difficulties are not fully appreciated at the start. The author has frequently rebuilt experimental set-ups two or three times before satisfactory results could be obtained. The literature of heat transmission is replete with illustrations of the confusing and misleading results of poor experimental technique. However, there have been many experienced investigators who have taken pains to secure the utmost accuracy in their work, and the intelligent use of their data, together with the fundamental principles and theory, will often save a costly series of experiments and redesign of the apparatus.

There is, therefore, a very real occasion for further study in the field of heat transmission by engineers and physicists, with a view to developing more adequate theories, clearer conceptions of the mechanisms involved, and more accurate data. Physicists in particular are in a position to render a valuable service in this field, because their training and methods are especially adapted to the refined technique and scientific perspective which are necessary for obtaining reliable data and correlating them into rational formulas.

In this connection, some very relevant remarks on the neglect by modern physics of pressing engineering problems are contained in an article on "Physics and Metallurgy," by Gillett and Russel, in the first number of the American Physical Society's new journal, *Physics*. As these authors put it, "What metallurgy needs is not the present crop of lop-sided atomic specialists, but general practitioners of physics who are interested in and keep somewhat abreast of the newer physics, but at the same time do not consider the law of gravitation beneath their dignity." Heat-transfer problems are listed among those needing immediate attention. From the engineering point of view, it would seem that physicists are fiddling while Rome burns. It is hoped that the present study will help to call the attention of laboratory workers to the many interesting problems in the field of heat transmission which offer opportunities for making significant contributions to this branch of engineering physics.

FUNDAMENTALS OF HEAT

An excellent presentation of the fundamentals of heat will be found in Preston's "Theory of Heat,"[2] or in Croft's "Practical Heat."[3] For the present purposes heat may be regarded as a manifestation of molecular motion. The exact nature of heat is as elusive as that of light or of electricity; it can be visualized only in terms of its effects. About all that can be said is that heat is a form of kinetic energy which manifests itself in physical bodies by such effects as increase of temperature, increase of volume, and change of state.

In English and American engineering practice, quantities of heat are measured in British thermal units (Btu). A Btu is usually defined as the amount of heat required to raise the temperature of one pound of water one degree fahrenheit. Since the specific heat of water varies slightly with the temperature, a "mean Btu" is sometimes defined more precisely as $^1/_{180}$ of the amount of heat required to raise the temperature of a pound of water from 32 F to 212 F. The thermal energy of one Btu is equivalent to the mechanical energy required to lift a weight of 778 pounds through a height of one foot.

Having conceived of heat in mechanical terms as due to molecular vibration, two methods by which it may be transmitted are immediately suggested: (1) The vibratory motion may be transmitted progressively from molecule to molecule by impacts (*conduction*), or (2) the vibrating masses may be conveyed bodily from one place to another by circulation or mixing within a fluid (*convection*). A third method, less obvious and direct, is by *radiation*. The mechanism of this process may be visualized by assuming that the vibrating molecules set up waves in the ether, which travel through space just as light or radio waves do.[4] These waves are transmitted, reflected, or absorbed in varying degrees by different substances and surfaces. When they are absorbed, the radiant energy is again converted into sensible heat.

These are the three fundamental heat-transfer processes. Evaporation and condensation are usually regarded as special cases of convection and conduction.

NOMENCLATURE

Before taking up the study of particular aspects of heat transfer, it will first be necessary to define some of the terms, and to discuss the general relations involved when several processes act in conjunction.

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[2] "Theory of Heat," by Thomas Preston. Fourth Edition, Macmillan Co., London and New York, 1929.

[3] "Practical Heat," by Terrell Croft. McGraw-Hill, New York, 1923.

[4] All of the phenomena of radiant energy cannot be explained in terms of a single mechanical theory. In modern physics the wave theory and the corpuscular or quantum theory are maintained as alternative descriptions of a process which can be expressed adequately only in mathematical terms. In many respects they are equivalent, and for practical purposes the wave theory provides a satisfactory conception of the mechanism.

The following definitions and symbols have been approved by the National Research Council Committee on Heat Transmission and the American Standards Association:

Area	A
Temperature, fahrenheit or centigrade	t
Temperature, fahrenheit absolute or Kelvin	T
Length of path of heat flow, thickness	L
Total quantity of heat transferred	Q
Time (when t is used for temperature)	τ
Thermal transmission (heat transferred per unit time)	q

$$q = Q/\tau$$

Thermal conductivity (heat transferred per unit time per unit area and per degree per unit length)	k
Thermal resistivity	$1/k$
Thermal resistance (degrees per unit of heat transferred per unit time)	R
Thermal conductance (heat transferred per unit time per degree)	C
Thermal conductance per unit area, sometimes called "unit conductance" (heat transferred per unit time per unit area per degree)	C_A
Surface coefficient of heat transfer; film coefficient of heat transfer, individual coefficient of heat transfer (heat transferred per unit time per unit area, per degree)	h
Overall coefficient of heat transfer; thermal transmittance per unit area (heat transferred per unit time per unit area per degree overall)	U

It is probable, and highly desirable, that these will be generally adopted. For one thing they are consistent with the terms used in electrical engineering, and will help to keep clear the analogy between the flow of an electric current and the flow of heat.

A very definite objective of this work is to convey a general perspective of the relative orders of magnitudes of the various forms of heat transfer by expressing all final results in homogeneous terms. Experience has shown that it is very helpful to think of all types of problems in terms of a common unit or coefficient. In most practical cases the heat is transferred by several processes acting in parallel or in series, and it is necessary to appreciate the relative significance of each. For example, heat is usually transferred across an air space by conduction, convection, and radiation in parallel, any one of which may be the controlling factor. And in a steam boiler the absorption of heat from the flue gases by the water takes place by three processes in series: forced convection from the gases to the heating surface, conduction through the metal wall, and free convection to the water on the other side. In all cases the convection coefficient on the gas side is the limiting factor, although a manufacturer of a copper-tube domestic heating boiler has recently been advertising the alleged fact that his boiler absorbs heat eight and a half times as fast as a steel boiler, because the conductivity of copper is eight and a half times that of steel.

In order, therefore, to put these various heat-transfer rates on a comparable basis they will be expressed in the form of coefficients (heat flow per unit time per unit area per degree temperature difference). A further advantage of this method is that several such coefficients can readily be combined, in cases where the heat flows by various processes in parallel or in series.

UNITS

English engineering units will be used, with the coefficients in British thermal units per hour per square foot per degree fahrenheit. Conductivities of materials will be based on a thickness or length of one inch. The conduction coefficient for any given thickness of material can then be obtained from the conductivity by dividing by the thickness in inches. Some authors use the foot as the unit of length, thus referring the conductivity to a cubic foot of the substance. While it is undoubtedly more consistent to use a single linear dimension for both the length and the area, there are two arguments in favor of the inch as the unit of length: (1) It is almost universally used in practice, as the "commercial conductivity," and engineers are accustomed to thinking in such terms; and (2) in most conduction problems the material is a few inches or a fraction of an inch in thickness, so that this unit is more convenient and gives a better idea of the actual magnitude of the rate of heat flow.

OVERALL VS. COMPONENT COEFFICIENTS

In connection with problems involving the transfer of heat by several different processes in combination, it has frequently been the practice to deal only with the overall coefficient, as from one fluid to another across a dividing wall. While such coefficients are undoubtedly convenient for many engineering purposes, this sort of treatment does not bring out the effects of the individual components, and the data are not of such general utility as when the "film" or surface coefficients are studied separately. The analysis of heat-transfer processes into the conduction, convection, and radiation components is just as logical and necessary as the resolution of electrical impedance into resistance, inductance, and capacitance is in electrical engineering. Hence in the present work the independent basic mechanisms will first be treated separately, after which it is a simple matter to combine them to get the overall coefficient for any particular case.

COMBINATION OF PARALLEL OR SERIES PROCESSES

For this purpose it is convenient to let the symbol C refer not only to the heat flow by pure conduction, but also to the "equivalent conductance" of radiation, convection, etc. That is, C is the heat transferred *by any process* per unit time per degree. Thus any individual coefficient may be changed to an equivalent conductance by multiplying by the corresponding area:

$$C_1 = A_1h_1$$

In the case of pure conduction, the conductance of a specific path may be expressed in terms of the conductivity of the material, the cross-sectional area, and the thickness, thus:

$$C_2 = \frac{k_2A_2}{L_2}$$

from which it may also be seen that k/L is the conduction *coefficient* (h) for a given thickness of material.

If the heat flows by several processes in parallel, the combined conductance is then

$$C = C_1 + C_2 + C_3$$

and in the case of series flow,

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

If the area for each process is the same, the individual coefficients may likewise be combined:

$$U = h_1 + h_2 + h_3 \text{ for parallel flow}$$

and

$$\frac{1}{U} = \frac{1}{h_1} + \frac{1}{h_2} + \frac{1}{h_3} \text{ for series flow.}$$

In many practical cases, as in the exchange of heat between two fluids through a thin metal wall, the conduction coefficient of the metal is so large that its reciprocal may be left out of the equation for series flow, so that

$$\frac{1}{U} = \frac{1}{h_1} + \frac{1}{h_2}$$

If the individual coefficients h_1 and h_2 are equal, U will be one-half of the value of either component. In any case, it is important to remember that *the overall coefficient for series flow is always less than the smallest individual coefficient.* For example, suppose that the coefficient for air flowing over a copper tube is $h_1 = 10$, and the coefficient for water circulating through the tube is $h_2 = 200$; then

$$\frac{1}{U} = \frac{1}{10} + \frac{1}{200} = \frac{21}{200}$$

or

$$U = 9.52$$

If now the water velocity is increased until $h_2 = 400$, the overall coefficient becomes $U = 9.75$. This should make clear the fact, which some engineers do not seem to appreciate, that there is no advantage in increasing an individual coefficient which is already high when the overall is limited by another process in series with it.

SUBJECT-MATTER

The following outline will indicate the types of problems which will be discussed in the succeeding articles, and the method of treatment.

The subject-matter will be divided into the following sections:

Conduction
Free or Natural Convection
Forced Convection
Radiation
Evaporation and Condensation.

It will be possible within the limited space available to treat only those aspects of each subject which are of most general significance or which occur most frequently in practice. However, carefully selected bibliographies will be added to each article, and referred to in the text, to point out where more detailed information on particular problems may be obtained.

CONDUCTION

Under the heading of Conduction, only the fundamental laws and formulas governing the steady flow of heat through simple bodies and combinations of paths will be discussed. Most engineers are not familiar enough with Heaviside's operational calculus, Bessel's functions, etc. to handle problems involving transient heating and cooling or complex boundary conditions, which are perhaps best left to mathematicians. On the other hand, an acquaintance with the thermal conductivities of various classes of materials, and the effects of such factors as temperature, pressure, impurities, heat treatment, and density is essential to a general perspective of heat-transfer processes. The significance of some of these effects is illustrated by the fact that the presence of a trace of arsenic in copper may reduce its conductivity by as much as 60 per cent.

Some years ago the author attempted to eliminate the conduction and convection (leaving only radiation) across an air space between two concentric cylinders by pumping the air down to a low pressure with a vacuum pump. The convection was effectively eliminated, but the conduction was still very considerable. It was then found that according to the kinetic theory the conductivity of a gas is independent of the pressure, down to extremely low pressures. However, if such a space is filled with a fine powder, even a metallic powder, radiation and convection are practically eliminated, and the conduction may be reduced below that of air alone if the pressure is pumped down to a moderately low value.

FREE CONVECTION

By free or natural convection is meant the transfer of heat by the circulation of a liquid or gas which is induced by the density changes due to heating or cooling. Under this heading it is proposed to discuss the mechanism of the process, the temperature and velocity distributions in the fluid moving over a surface, and the effects of size, shape, orientation, temperature, and other factors upon the convection coefficient.

In connection with free-convection problems, what is usually wanted is the surface coefficient, or the heat transfer per unit time per unit area per degree difference in temperature between the surface and the main body of the fluid in contact with it. Once the proper value of the coefficient is obtained, it is an easy matter to calculate the heat flow by substituting in the equation

$$q = Ah(t_1 - t_2)$$

(heat flow = area × coefficient × temperature difference). However, the coefficient is influenced by many factors, and it is perhaps the principal objective of the study of free convection to appreciate the effects of these variables and to formulate them so that the coefficient for a definite set of conditions may be calculated. To this end general formulas will be given, from which the convection coefficients may be obtained for various bodies in any gas or liquid, as well as simplified formulas and curves for specific cases occurring commonly in practice.

FORCED CONVECTION

In the typical forced-convection problem the velocity of the main body of the fluid is large compared with that of the natural-convection currents generated at the heating surface. Formulas for the convection coefficient are therefore usually expressed in terms of the main fluid velocity, together with certain other factors such as the viscosity and specific heat. There is, however, no sharp line of demarcation between the two processes, and in some cases where the nominal velocity is low, the heat transfer is governed mainly by the effect of the temperature difference in setting up natural-convection currents in the surface film. For example, in oils or water flowing through pipes at velocities less than about one foot per second, the coefficient may be independent of the velocity. Thus some ostensible forced-convection problems should be treated as cases of free convection, or as combinations of the two.

Most of the work on forced convection has been concerned with fluids flowing through pipes, because of the industrial importance of such problems. Considerable data are also available on fluids flowing across wires, cylinders, and plane surfaces. More information is needed on the heat transfer from surfaces to fluids at very high velocities, particularly in connection with aeronautical work. In fact, the general problem of forced convection is closely associated with the problems of hydrodynamics and fluid flow. In many heat-transfer problems the pressure drop and power required to circulate the fluid must be taken into account in the economic balance. It is sometimes stated that turbulence is very desirable in a heat exchanger, in order to secure high rates of heat transfer, but there are many indications that higher coefficients might be obtained more efficiently by using higher velocities with the minimum amount of turbulence. However, where pressure drop is not important, a heat exchanger may be made more compact and effective, for a fixed rate of flow, by promoting turbulence.

RADIATION

The aspects of radiation which are of most interest to engineers are the laws governing the exchange of radiant energy between bodies of various configurations, and the factors affecting the emissive and absorptive powers of surfaces and masses of materials. The laws and fundamental constants are pretty well determined, but there is a definite need for more information on the emissivities of various surfaces and of flames.

EVAPORATION

Evaporation seems to have been studied less than any other heat-transfer process. Until very recently there have been almost no data available on anything but large industrial evaporators. Some of the author's associates have been conducting an experimental study of the evaporation of refrigerants, and a few data have been received from other laboratories. The mechanism of the process has been pieced together to some extent from scattered sources, and some new facts, as well as some interesting new problems, have been brought to light.

For example, it appears that the phenomenon of liquid superheating is one of the principal factors controlling the heat-transfer coefficient. There is no discontinuity in the temperature gradient at a metal-liquid interface, but the liquid in the surface film is heated considerably above the boiling point. The greater part of the temperature drop from the metal to the main body of the liquid occurs in this superheated film. Some of the factors affecting this phenomenon have been isolated, and it has been found possible to increase the coefficient by reducing the tendency of the liquid to superheat, but there are still some rather mysterious features about it.

CONDENSATION

The mechanism of condensation has received considerable study, and the data for condensing steam have been fairly well organized. The practical application of the results, however, is very much hampered by the fact that the coefficients are greatly affected by the percentage of air or other non-condensables, which is difficult to predict or to measure.

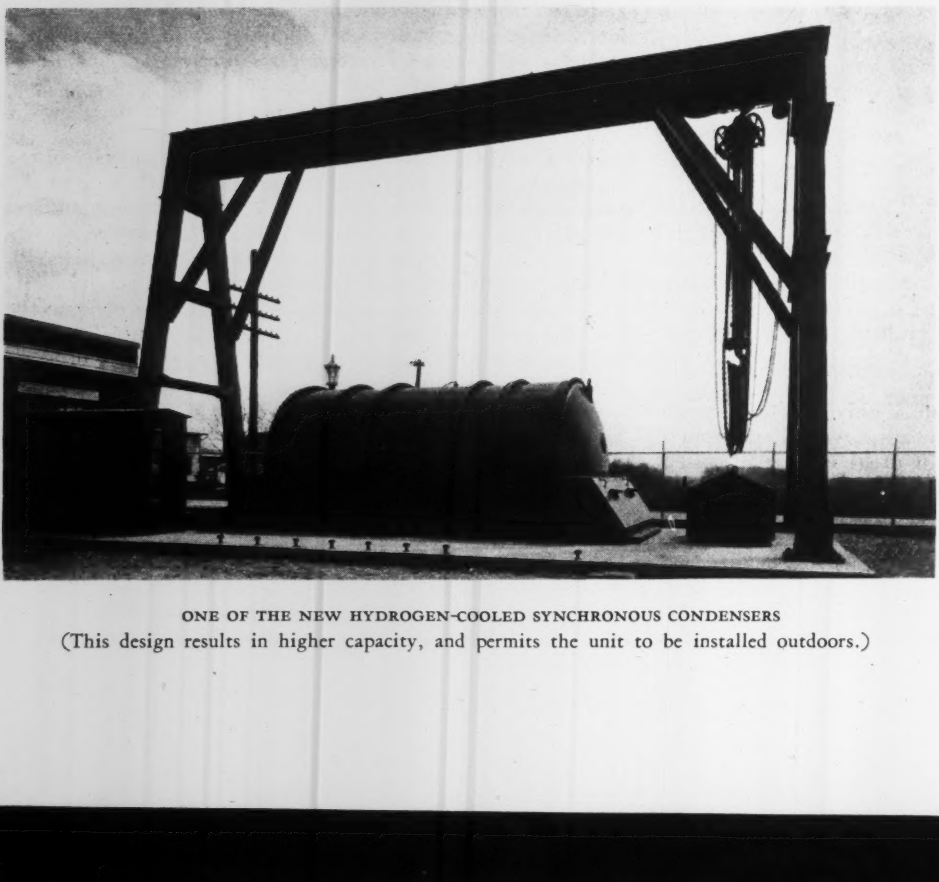
A few data are available on the condensation of other vapors, and a theoretical formula has been developed for predicting the coefficient in terms of the properties of the fluid, etc.

REPRESENTATIVE COEFFICIENTS

Before taking up the separate study of these heat-transfer processes in greater detail, it will perhaps help to develop a perspective of the relative magnitudes if a list of representative coefficients for the conditions which commonly occur in practice is given. The above coefficients are therefore offered as typical values, although some of them may vary widely with the temperature or velocity.

	Btu per hr per sq ft per deg F
Conduction through $^{1}/_{16}$ in. of copper	42,600
Conduction through 1 in. of corkboard	0.30
Conduction through $^{1}/_{16}$ in. of oil	1.50
Conduction through $^{1}/_{4}$ in. of air	0.67
Free convection, plane surface in air	0.60
Free convection, plane surface in water	150
Forced convection, water in pipe	1,200
Forced convection, air over tubes	8
High-temperature "black-body" radiation	8
Low-temperature "black-body" radiation	1
Evaporating water	1,000
Evaporating refrigerant	150
Condensing steam	2,000
Condensing organic liquids	300

As an example of the effect of some of the variables, it can be stated that the forced-convection coefficient for a fine wire in air may be 100 times as large as that for a 10-in. pipe, with all other conditions the same. It is very necessary, therefore, to understand these effects in order to obtain a reasonable degree of accuracy.



ONE OF THE NEW HYDROGEN-COOLED SYNCHRONOUS CONDENSERS
(This design results in higher capacity, and permits the unit to be installed outdoors.)

A STEAM CHART *for* SECOND-LAW ANALYSIS

A Study of Thermodynamic Availability in the Steam Power Plant

By J. H. KEENAN[1]

IT IS HARDLY more than ten years since the beginning of a revolution in the exposition of the thermodynamics of fluid flow. This revolution consisted not in the discovery of a new principle but in the recognition of the importance of an old one. The principle is summed up in the energy equation of continuous flow, which, when expressed in ft-lb per lb, is

$$U_1 + p_1v_1 + \frac{V_1^2}{2g} + z_1 = U_2 + p_2v_2 + \frac{V_2^2}{2g} + z_2 - Q + W$$

or

$$h_1 + \frac{V_1^2}{2g} + z_1 = h_2 + \frac{V_2^2}{2g} + z_2 - Q + W \quad \ldots\ldots [1]$$

where U = internal energy per lb of fluid
h = enthalpy or total heat per lb of fluid
p = pressure in lb per sq ft abs
v = specific volume in cu ft per lb
V = velocity of fluid, ft per sec
z = potential energy above datum, ft-lb per lb
Q = heat transferred to fluid from outside source per lb of fluid
W = work done against outside forces per lb of fluid, and
Subscripts 1 and 2 refer to conditions at sections 1 and 2, Fig. 1.

Fully nine-tenths of all mechanical-engineering problems in thermodynamics involve in their solution the continuous-flow analysis. But Equation [1] has done more than to play its part as an analytical tool. It has brought precision and simplicity into the exposition of engineering thermodynamics. It has removed all question as to the definition of enthalpy[2] or total heat (namely, $U + pv$)—particularly has it eliminated the definition involving heat put in at constant pressure. It has eliminated much complex and fruitless reasoning concerning friction and irreversible processes in general, for its validity does not depend on the assumption of reversibility for any processes which may be going on between section 1 and section 2. It has nailed down the concept and definition of heat, a quantity which in earlier days was frequently confused with internal energy and even with work in irreversible processes. In short, Equation [1] is the simplest and most inclusive statement of the first law of thermodynamics for continuous flow of fluids.

The engineering state of mind with regard to the second law of thermodynamics is at present in that confused, contradictory, and uncertain state which characterized first-law reasoning two decades ago. The engineer realizes, of course, that of two equally inefficient stages in a steam turbine the stage at the higher pressure does less damage to his overall performance than does the stage at lower pressure. He has codified this statement in the so-called reheat factor. He realizes that temperature differences between extracted steam and feedwater in extraction heaters cause losses in availability, but he finds the computation of such losses an involved process quite unlike the usual run of analyses which he encounters. He knows that a Btu of enthalpy in his circulating-water outlet is less marketable and less valuable than a Btu of enthalpy in his steam main, but a quantitative statement of this fact, particularly in the case of complex cycles, is not easily obtained. It appears that there is a need for an Equation [2] expressing the second law of thermodynamics for continuous flow much as Equation [1] expresses the first law.

AVAILABILITY

Heat engines as we know them must work within an environment, an indefinite atmosphere. This atmosphere has an absolute pressure, p_0, and an absolute temperature, T_0. Presumably this T_0 is, in practice, the lowest temperature at which we can find an indefinite amount of material to which we may reject heat. It is obvious that a body of fluid at rest at pressure p_0 and at temperature T_0 is in complete equilibrium with its environment. Such a condition might be thought of as a "dead state."

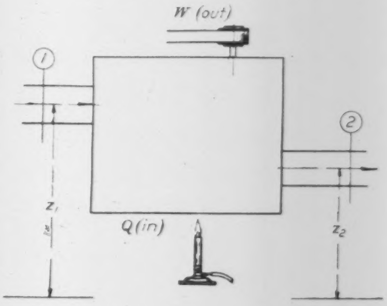


FIG. 1 THE CONTINUOUS-FLOW PROBLEM

Let us define the availability of a pound of fluid in continuous flow at condition 1 (Fig. 1) as the maximum amount of useful work which any heat engine, however simple or complex, can deliver against outside forces to a shaft, or to storage in an elastic-spring reservoir, or to any other mechanical device, by changing the condition of the flowing fluid to the dead state where $p = p_0$, $T = T_0$, and $V = 0$. It is assumed, of course, that no heat can be supplied to the fluid except from the environment at temperature T_0.

We can simplify the problem for the moment by assuming negligible kinetic energies. Starting from the above definition of availability, it is shown in the Appendix that for this simplified case the availability at condition 1 is $(h_1 - T_0s_1) - (h_0 - T_0s_0)$, where h_0 and s_0 are respectively the enthalpy and entropy of a pound of fluid at condition p_0, T_0. Likewise at condition 2 the availability is $(h_2 - T_0s_2) - (h_0 - T_0s_0)$; and the change in availability per pound of fluid that occurs between section 1 and section 2 is

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[2] I speak here only for the mechanical engineer. In the field of physical chemistry there has been no confusion concerning the definition of enthalpy.

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$$(h_2 - T_0s_2) - (h_1 - T_0s_1)$$

Let us adopt the symbol b for the function $(h - T_0s)$. Then the change in availability between condition 1 and condition 2 is $b_2 - b_1$. Since kinetic energy is a completely available form of energy, this last statement may now be expanded to include it: thus

$$[\text{Availability increase}]_1^2 = \left(b_2 + \frac{V_2^2}{2g}\right) - \left(b_1 + \frac{V_1^2}{2g}\right). [2]$$[3]

If the sum of the 1-subscript terms exceeds that of the 2-subscript terms, then the increase is negative, that is, there is a decrease in availability between 1 and 2.

If a number of fluid streams enter a piece of apparatus the gain in availability which can be credited to the processes going on in it is the difference between $\Sigma w \left(b + \frac{V^2}{2g}\right)$ at exit and at entrance (w being the number of pounds per second flowing in any one stream). As usual, if this difference is negative there has been a decrease in availability during the passage through the apparatus.

Equation [2] was, I believe, first derived and published by Darrieus in June, 1930.[4] It promises to be as revolutionary in its effect on thermodynamic reasoning as Equation [1] has been. As the Mollier or h, s diagram has been extremely useful wherever the energy equation of continuous flow is necessary to an analysis, so a b, s diagram (Fig. 2) will be useful wherever the availability equation is to be used.

THE SIMPLE POWER-PLANT CYCLE ON THE b, s DIAGRAM

Let us assume for simplicity that changes in $V^2/2g$ in Equation [2] are negligible and analyze a few cases for changes in availability.

It is obvious that for a simple reversible Rankine cycle *ONMO* (Fig. 3) the change in availability for each pound of fluid during the constant-entropy expansion is the change in

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[3] To complete the analogy with Equation [1] it is necessary to include the effect on availability of changes in potential energy above the datum. This is done in the Appendix.

[4] *Revue Generale de l'Electricite*, June 21, 1930, vol. 27, pp. 963–968. It appeared in translation in *Engineering*, September 5, 1930, pp. 283–285.

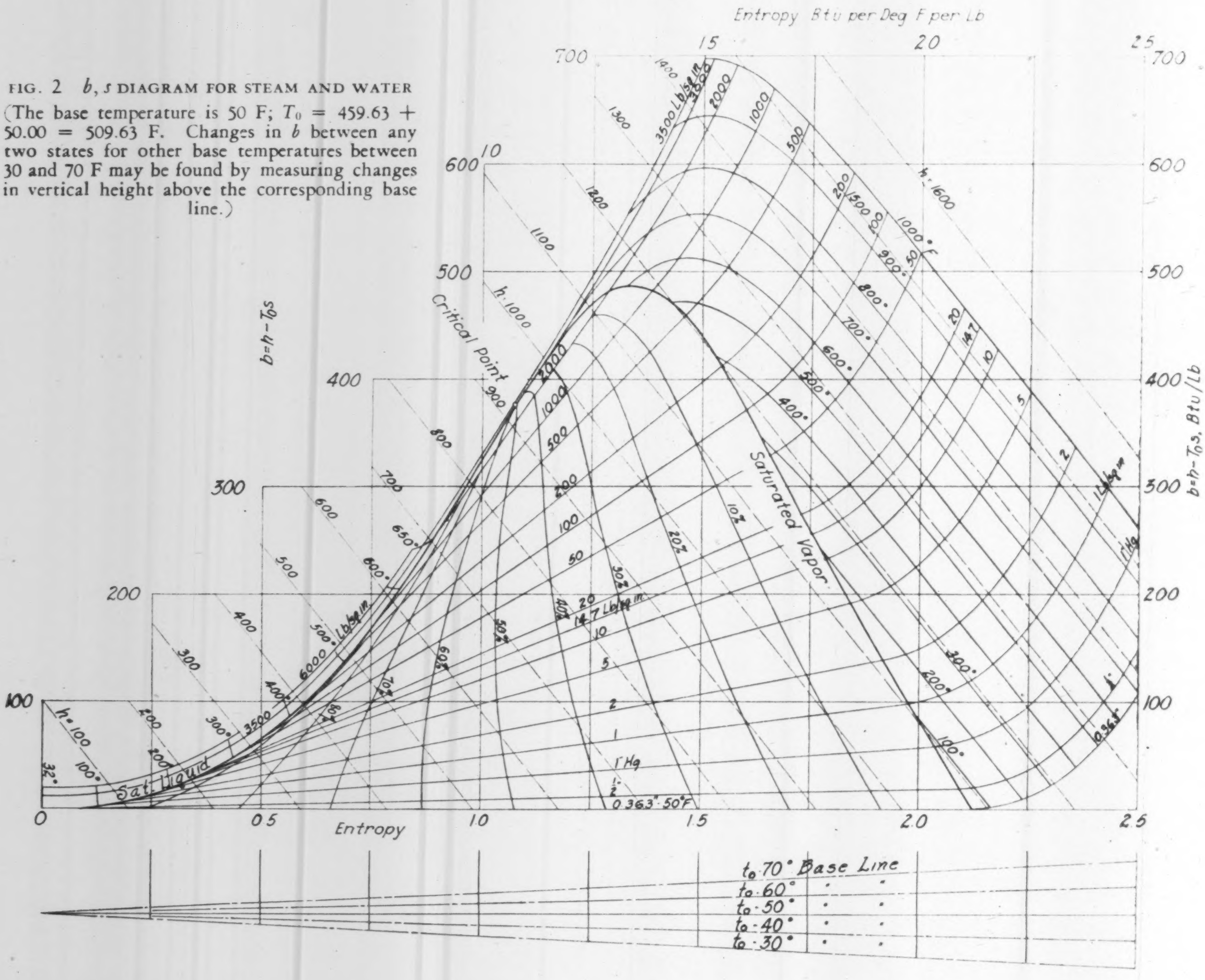


FIG. 2 b, s DIAGRAM FOR STEAM AND WATER

(The base temperature is 50 F; T_0 = 459.63 + 50.00 = 509.63 F. Changes in b between any two states for other base temperatures between 30 and 70 F may be found by measuring changes in vertical height above the corresponding base line.)

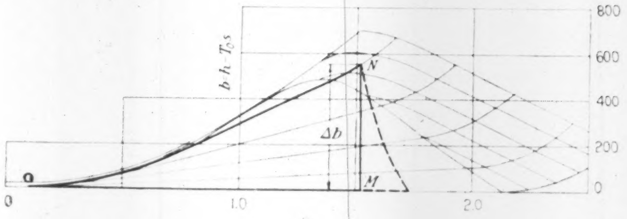


FIG. 3 SIMPLE POWER-PLANT CYCLES, REVERSIBLE AND IRREVERSIBLE

b, or $b_M - b_N$. Since b_N is larger than b_M, the difference is negative and the change has been a decrease. For any constant-entropy change the change in b, which by definition is $(h - T_0 s)$, is equal to the change in h because the change in the second term is zero. But from the energy equation we find that the work for this constant-entropy case is

$$W = -(h_M - h_N) = -(b_M - b_N)$$

the minus sign indicating that the work is positive (done by the fluid) when the change in h or b is negative.

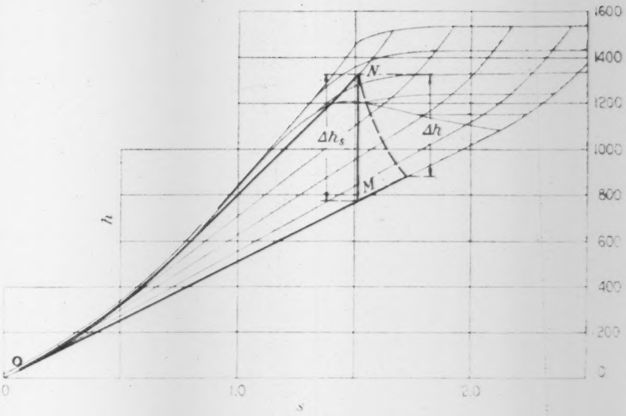
The above equation might have been arrived at by reasoning from our definition of availability, namely, the maximum work which any heat engine can deliver against outside forces while changing our fluid from condition p, T, h, etc. to condition p_0, T_0, h_0, etc. without involving any heat reservoir at a temperature other than T_0. By the usual Carnot reasoning it may be shown that this maximum work will be obtained by following any system of reversible paths between p, T, h, and p_0, T_0, h_0. Obviously, the constant-entropy line NM might be part of such a system of paths in that it is reversible and involves the use of no heat reservoir. Thus the maximum work which can be obtained between M and the dead state is less than that between N and the dead state by exactly the amount of work done between N and M. Whence it follows, $-(b_M - b_N) = W$.

Since b is a property of the fluid, the change in b around any closed cycle must be zero. Or, the sum of the losses or reductions in availability throughout any closed cycle must be of equal and opposite magnitude to the sum of the gains in availability in that cycle. Again using the simple Rankine cycle, expanding to T_0 and within the mixture region, it is found that all change in b between the steam supply and the condenser hotwell occurs during the expansion, there being no loss in availability in the condenser. Consequently the gain in availability between the hotwell and the steam main must be equal to the loss during the expansion. This is obvious from the diagram.

If we introduce some irreversibility into the expansion to T_0 we find that the change in availability remains the same (provided that the expansion ends within the mixture region). This must be so because the availability increase between condenser and steam main remains unchanged, and this increase must equal, in magnitude, the decrease during expansion.

The work done during the expansion is now less than in the reversible case and is equal, according to the energy equation, to

$$W = -\Delta h < -\Delta b$$



The ratio of work done to decrease in availability for any irreversible adiabatic process is thus less than unity, or

$$\frac{W}{-\Delta b} = \frac{\Delta h}{\Delta b} < 1$$

Darrieus suggests that this ratio be called the efficiency of a turbine or a turbine stage, and that it supplant the better-known efficiency, $W/\Delta h_s$ (Δh_s being the constant-entropy drop in enthalpy between the initial state and the final pressure). It will be shown below that this ratio is a valuable addition to our thermodynamic vocabulary, but to avoid confusion it would be well not to give it a name already firmly attached to another definition. I shall call it, for want of a better name, effectiveness: thus,

$$\text{Effectiveness} = \frac{\text{work}}{\text{decrease in availability}}$$

RESUPERHEATING AND EXTRACTION FEEDWATER HEATING

For more complex cycles the b, s chart permits a ready allocation of losses in availability throughout the power plant. Each device through which passes all or part of the stream of water or steam can be charged with a very definite portion of the total availability provided by other devices. For instance, availability is added from outside the fluid system by the feed pumps, economizer, boiler, superheater, and resuperheater, and an amount equivalent to the total of all these additions is lost in the turbines, condenser, feedwater heater, etc. Only in the case of the turbine is any of the availability converted to useful work, and there only part is so converted. Decreases in availability in excess of work done constitute complete and irrecoverable losses.[5]

The example worked in Fig. 4 shows that the major increase in availability occurs in the boiler, superheater, and resuperheater. Minor gains occur in the feed pumps, in this case about $^1/_2$ per cent of the total. On the energy basis the feed-pump work (3.2 Btu per lb) is only $^1/_4$ per cent of the heat added (1308.8 Btu per lb). Note that the availability analysis gives a truer picture of the importance of feed-pump work than does the energy analysis. The difference between these two percentages tells us quantitatively what we have long appreciated qualitatively: that a given amount of work is

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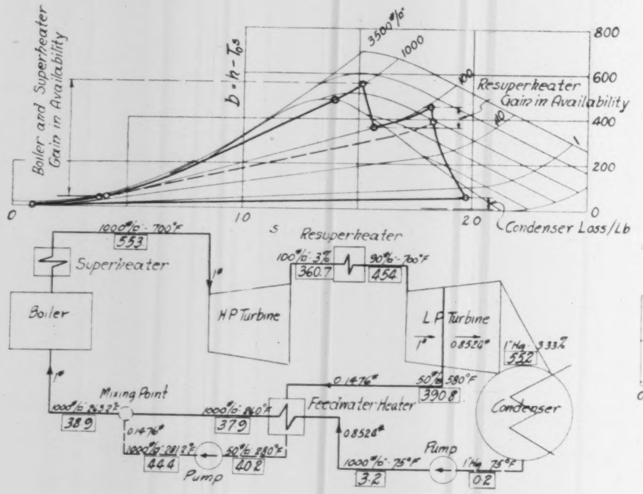
[5] Kinetic energies at the sections studied are again assumed to be negligible. It should be noted that no special treatment of heat losses is necessary. Except in the case of heating and cooling devices, such as boiler, superheaters, condensers, etc., the conditions may be quite adiabatic and yet be accompanied by important losses in availability. Where heat losses do occur the total loss in availability is found as usual from the change in b.



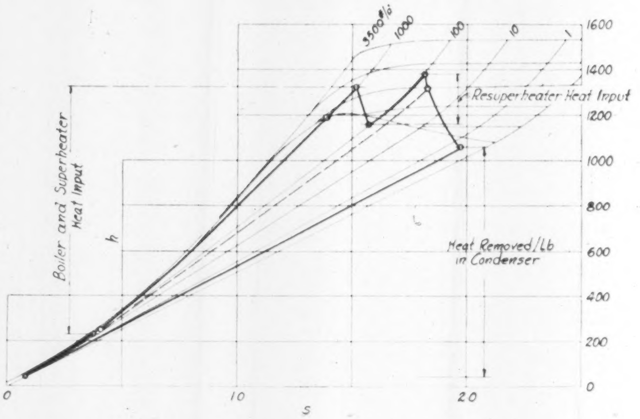


FIG. 4 RESUPERHEATING AND EXTRACTION CYCLE

(Figures in boxes on the diagram of the power plant are the values of b at those points. The calculated results are all per pound of steam entering the turbine. See availability and energy tables below.)

INCREASE IN AVAILABILITY = $(\Sigma wb)_{\text{out}} - (\Sigma wb)_{\text{in}}$

Increases in Availability:		Btu	Per cent of total
Main feed pump: 0.8524 (3.2 — 0.2)	=	2.6	0.42
Drip pump: 0.1476 (44.4 — 40.2)	=	0.6	0.10
Boiler and superheater: 553.1 — 38.9	=	514.2	84.19
Resuperheater: 454.1 — 360.7	=	93.4	15.29
Total……		610.8	100.00

Decreases in Availability:				Effectiveness per cent
H.p. turbine: 360.7 — 553.1	=	—192.4	31.50	85.7
L.p. turbine to extraction point: 390.8 — 454.1	=	— 63.3	10.36	90.2
L.p. turbine, extraction point to exhaust: 0.8524 (55.2 — 390.8)	=	—286.0	46.83	77.9
Condenser: 0.8524 (0.2 — 55.2)	=	— 46.9	7.68	
Extraction heater: (0.8524 × 37.9 + 0.1476 × 40.2) — (0.1476 × 390.8 + 0.8524 × 3.2) = 38.26 — 60.45	=	— 22.2	3.63	
Mixing point……		negligible		
Total……		—610.8	100.00	

$$\text{Turbine effectiveness} = \frac{445.0}{192.4 + 63.3 + 286.0} = 82.2 \text{ per cent}$$

Power-plant (turbine, heater, condenser combination) effectiveness = 445.0/610.8 = 72.8 per cent

ENERGY INPUT (or Heat Added + Work Done on) = $(\Sigma wh)_{\text{out}} - (\Sigma wh)_{\text{in}}$

Energy Input:		Btu
Main feed pump: 0.8524 (46.0 — 43.0)	=	2.6
Drip pump: 0.1476 (253.2 — 249.0)	=	0.6
Boiler and superheater: 1324.9 — 234.8	=	1090.1
Resuperheater: 1378.7 — 1160.0	=	218.7
Total energy input……		1312.0
Heat input……		1308.8

Energy Output:		Work, Btu	Efficiency, per cent
H.p. turbine: 1160.0 — 1324.9	=	—164.9	79.4
L.p. turbine to extraction point: 1321.6 — 1378.7	=	— 57.1	82.2
L.p. turbine, extraction point to exhaust: 0.8524 (1060.0 — 1321.6)	=	—223.0	77.0
Total……		445.0	
Net work of cycle = turbine work — pump work	=	441.8	

Power-plant thermal efficiency (assuming 100 per cent efficient boiler and resuperheating plant) = 441.8/1308.8 = 33.8 per cent

more costly and more valuable than an equal amount of heat. Thus the b, s chart shows the compressed-liquid region to better advantage than does the Mollier chart.

Decreases in availability occur throughout the turbine, in the condenser, and in the extraction heater. In the turbine these decreases can be accounted for by work done and by irreversibility consisting of friction losses. In the condenser and feedwater heater the loss is due entirely to irreversibility of a different sort, namely, heat transfer across a finite temperature difference.[6] In this case, with a 50 F river temperature and a 79 F condensing temperature, the loss in availability in the condenser is 7.7 per cent of the total for the plant. Similarly the feedwater heater shows a difference between total availability entering and total availability leaving of 32.2 Btu per lb, or 3.6 per cent of the total. There should be a similar loss in availability due to dissipation of temperature differences at the point where the heater drip joins the main feed line, but this loss is too small to appear in the first decimal place. Availability losses must be similarly calculated for, and charged to, pipe lines, valves, and any other devices which introduce irreversible processes. Such losses have been omitted from the problem for the sake of simplicity, but they may be obtained, as usual, from the change in b on the b, s chart.

EFFECTIVENESS AND EFFICIENCY

Now, consider a partial expansion from M to P, Fig. 5. The reduction in availability is ${}_M\Delta b_P < \Delta h_s$; the efficiency is $\Delta h/\Delta h_s$; the effectiveness is $\Delta h/\Delta b$; therefore

effectiveness > efficiency

The effectiveness is greater than the efficiency because the reduction in availability in going from M to P is less than the work of a reversible engine expanding the fluid from M to Q. At first hearing it seems paradoxical to say that an irreversible engine operating between M and pressure QP causes less loss in availability than a reversible engine operating between the same limits. Yet that is the basic concept of the reheat factor, namely, that by virtue of the irreversibility between M and P

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[6] The change in availability in a feedwater heater is (as always) [$\Sigma(wb)$ leaving] — [$\Sigma(wb)$ entering]. This difference is negative, indicating a decrease in availability which is due to the irreversible heat flow from steam to water. The function of the feedwater heater is to increase the gain in availability realized in the boiler plant per unit of heat added there.

the available energies in stages subsequent to P are increased and the change in availability that occurs between M and P is correspondingly decreased. We may say, then, that the effectiveness exceeds the efficiency because the effectiveness includes the reheat effect.

Consider two turbine stages of equal available energy (Δh at constant s) of 100 Btu per lb and equal efficiency ($\Delta h/\Delta h_s$) of 70 per cent. The steam enters the first stage at 500 lb per sq in., 700 F (state M, Fig. 5), and expands to 200 lb per sq in.

The steam enters the second stage at 10 lb per sq in., 4 per cent wet (state R), and expands to 2.02 lb per sq in.

From the data and the b, s diagram we find the following:

	Δh at const. s	Δh	Δb	Efficiency	Effectiveness
High-pressure stage.	100	70	85.7	70%	81.7%
Low-pressure stage. .	100	70	96.1	70%	72.8%

Though the efficiencies of the two stages are equal, the effectiveness of the high-pressure stage is considerably greater than that of the low-pressure stage. There is, of course, nothing new in this revelation. Every power-plant engineer and every turbine engineer knows that he can afford inefficiencies in the high-pressure end of his turbine better than in the low-pressure end. By working this problem backward we can show that the high-pressure turbine efficiency can be lowered to 58.2 per cent before the effectiveness of the high-pressure stage will equal that of the low-pressure stage. Thus the effectiveness tells how well each stage does its job as a part of the whole—the efficiency refers to the stage alone.

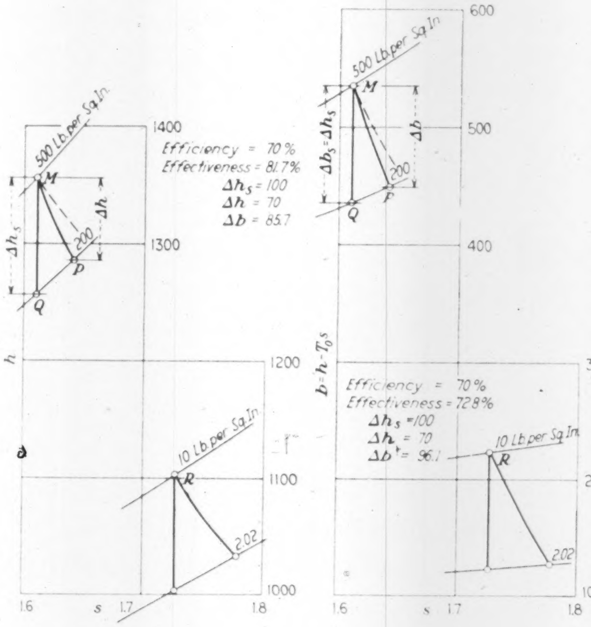

FIG. 5 HIGH-PRESSURE TURBINE STAGE COMPARED WITH A LOW-PRESSURE STAGE

(Though the efficiencies are the same, the effectivenesses are quite different. The stage represented by the broken line between 500 lb per sq in. and 200 lb per sq in. has the same effectiveness as the low-pressure stage.)

Darrieus explains that effectiveness is the ratio of work actually delivered by the fluid expanding between M and P to work which would be delivered by an ideal heat engine operating along the same path and between the same states. Efficiency, on the other hand, is the ratio of work actually delivered by the fluid expanding between M and P, to the work which would be delivered by an ideal engine or turbine restricted to a reversible adiabatic path between M and pressure QP.

Now a simple reversible engine cannot work between states M and P without introducing irreversible processes (assuming no heat source at any temperature level other than T_0). But by slightly complicating the engine, we may cause the fluid to leave at P without introducing irreversibility. For instance, we could expand the fluid in a reversible turbine to Q and take out work Δh_s. Some of this work may now be used to run a heat pump to pump heat from the sink, at temperature T_0, to the exhaust fluid from our engine to raise its temperature at constant pressure from Q to P. At any intermediate temperature T the amount of work which must be done on the reversible heat pump is equal to

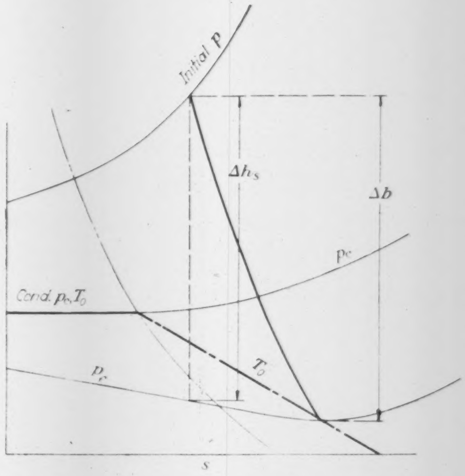

FIG. 6 EXPANSION ENDING IN THE SUPERHEAT REGION

(Maximum net work is obtained from the actual engine by expanding to T_0. Isentropic expansion to p_f gives less net work than isentropic expansion to T_0 followed by isothermal expansion to p_f. Hence Δh_s is not the work of an ideal engine.)

$$[(T - T_0)/T]\, dh = dh - T_0 ds$$

Integrating, we get

$$\begin{aligned}
\text{Net work delivered} &= [\text{turbine work}] - [\text{pump work}] \\
&= [h_M - h_Q] - [h_P - h_Q - T_0(s_P - s_Q)] \\
&= h_M - h_P + T_0(s_P - s_M) \\
&= (h_M - T_0 s_M) - (h_P - T_0 s_P) \\
&= b_M - b_P
\end{aligned}$$

The path MP followed by the steam in the actual engine may also be followed by the fluid in our reversible engine by making each infinitesimal decrement of pressure in the fluid stream include a constant-entropy expansion followed by heating at constant pressure back to the line MP, the heat being obtained from our reversible heat pump. By the usual Carnot reasoning it may be shown that the net work done by the reversible engine following path MP is equal to the net work done by the reversible engine following path MQP. Thus the net work done by the reversible engine following the same state path as the fluid in the actual engine is

$$b_M - b_P$$

which is the denominator in the definition of effectiveness.

The effectiveness is thus more truly a ratio between actual and ideal engines than is the efficiency, because the ideal engine of the effectiveness denominator works along exactly the same path as does the actual engine; the ideal engine of the efficiency denominator works along an entirely different path from that of the actual engine. In fact, the efficiency owes its long life and usefulness to the simple Rankine cycle and to the fact that most power-plant cycles end within the steam dome, where, if the exhaust temperature is chosen as T_0, the overall efficiency and overall effectiveness are the same thing.

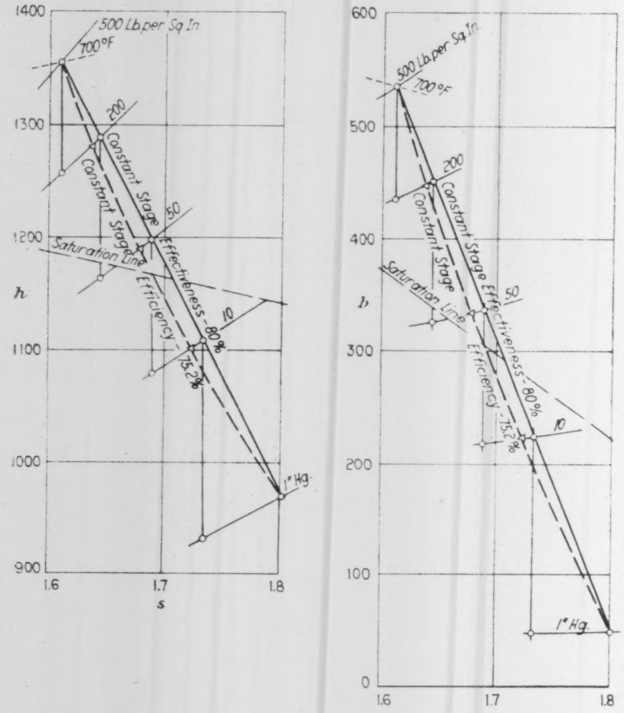

FIG. 7 COMPARISON OF A CONSTANT-STAGE-EFFICIENCY CONDITION CURVE WITH A CONSTANT-STAGE-EFFECTIVENESS CONDITION CURVE FOR A FOUR-STAGE TURBINE

(The two turbines have equal overall efficiencies and equal overall effectivenesses. The constant-stage-effectiveness condition curve is a straight line on both diagrams.)

Let us suppose, for a moment, that we have a power plant running under such conditions that our engine exhausts a superheated vapor (Fig. 6). We have a choice of exhaust conditions. We may stop the expansion in the engine at the condensation pressure p_c but above the condensation temperature T_0, or we may continue the expansion to T_0 at a pressure below p_c. Assuming the difference between these two choices to be sufficiently large, we would choose the latter despite the fact that it involved constant-temperature compression to p_c, because the compression work involved would be less (because of smaller volumes) than the additional expansion work obtained.

The ideal engine of the efficiency ratio would now work along a reversible adiabatic (constant-entropy) path between condition P and pressure p_f, the final pressure of the expansion. But there is nothing ideal about this engine in the thermodynamic sense, because it would obviously do better if it ceased to be adiabatic on crossing T_0 and took from the surroundings sufficient heat to carry through the remainder of the expansion at constant temperature. The efficiency would consequently have little justification as a measure of perfection.

The overall efficiency of a steam turbine having constant stage efficiency throughout is markedly greater than the efficiency of the individual stages; but the overall effectiveness of a turbine having constant stage effectiveness is equal to the effectiveness of the individual stages. Also the overall effectiveness of a turbine having stages with various effectivenesses is the weighted mean (weighted on the basis of availability drop) of the effectivenesses of the individual stages, thus:

$$\text{Overall effectiveness} = e = \frac{\Sigma\Delta h}{\Sigma\Delta b} = \frac{\Delta h_1 + \Delta h_2 + \Delta h_3 + \ldots}{\Delta b_1 + \Delta b_2 + \Delta b_3 + \ldots}$$

$$= \frac{\Delta h_1}{\Delta b_1} \times \frac{\Delta b_1}{\Sigma\Delta b} + \frac{\Delta h_2}{\Delta b_2} \times \frac{\Delta b_2}{\Sigma\Delta b} + \frac{\Delta h_3}{\Delta b_3} \times \frac{\Delta b_3}{\Sigma\Delta b} \ldots$$

$$= e_1 \frac{\Delta b_1}{\Sigma\Delta b} + e_2 \frac{\Delta b_2}{\Sigma\Delta b} + e_3 \frac{\Delta b_3}{\Sigma\Delta b} + \ldots$$

where e_1, e_2, e_3, etc. are the effectivenesses of the individual stages.

A corollary of the preceding paragraph is that the condition curve of a constant-stage-effectiveness turbine is a straight line when plotted on either the h,s diagram or the b,s diagram (Fig. 7), a fact which will be useful in certain analytical studies.

Despite its shortcomings, the efficiency ratio has played a useful and reasonably adequate part in the study of simple power-plant cycles. The overall efficiency of one turbine plant could be compared with that of another and, if proper allowances were made for the effect of superheat, final pressure, etc., the relative excellence of the two turbines would be shown. But when complications such as regenerative feedwater heating and resuperheating were added to the power-plant cycle, efficiency became useless as a measure of turbine perfection. The use of efficiency for comparisons became awkward and unreliable. For instance, a turbine designer might well complain if the efficiency of his extraction turbine was compared with the efficiency of a competitor's non-extraction turbine to determine relative excellence. The non-extraction turbine would have the advantage of reheat from all losses in the high-pressure stages, while the extraction turbine would lose the advantage of reheat from losses incurred by extracted steam.[7] There can be no such objection if the effectiveness of the two machines is compared. The high-pressure stages are automatically credited with reheat effect in both machines, and the overall results are comparable.

Perhaps it is time to pause and find some justification for the efficiency ratio before we rashly abandon it. The effectiveness of a turbine stage computed from a test and using, say, the river temperature as T_0 is radically different from the effectiveness of the same stage working with equal velocities at a much lower initial enthalpy. On the other hand, experience shows that the efficiency of a turbine stage is much more independent of the initial conditions (barring expansion into the moisture region) than is its effectiveness on this basis. When using effectiveness in the study of a single stage it would be well to set T_0 at the actual exhaust temperature, in which case it will be found that Δb and Δh_s are in very close agreement except for extremely low stage efficiencies. On this basis it is probable that the constancy would be about equally good for the two ratios. It appears that the strongest defense which can be made of stage efficiency is that it is easy to compute. The denominator of the ratio is known before the test is run or the stage designed, and it remains only to put the work in the numerator as soon as it has been measured or computed. Furthermore, it is a good approximation to the thermodynamically more logical stage effectiveness based on a T_0 equal to the final-stage temperature. These two ratios become less distinguishable the smaller the enthalpy drop across the stage, and both approach the hydraulic efficiency (work/Δpv) as the pressure drop approaches zero. The efficiency, then, can justify itself for use in studies of turbine-stage performance, but it must be abandoned as a measure of overall performance in anything but the simplest steam-power-plant cycles.

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[7] Other devices have been tried, such as Btu consumption. But it is obvious that Btu consumption is determined by many factors other than relative turbine perfection. Thus extraction turbines cannot be compared with non-extraction turbines through their Btu consumption.

ANALYSIS OF TURBINE ELEMENTS

The turbine designer will frequently wish to determine the relative importance of irreversibility in various elements of his turbines. He can ask himself whether his high-pressure packing or his throttle valve causes the greater loss in availability. The answer to such questions can be obtained readily by the methods outlined above.

There are, however, many turbine elements, nozzles and buckets for example, in which the assumption of negligible kinetic energies, hitherto made in our specific examples, would beg the question. In such cases we must return to the more complete Equation [2], which may be written

$$\text{Decrease in availability} = w\,[(b_e + V_e^2/2g) - (b_x + V_x^2/2g)]$$

where subscripts e and x refer respectively to entrance and exit. It is obvious that for a constant-entropy (reversible) expansion the decrease will be zero.

Another interesting example is the diffusing exhaust hood—a diverged exhaust passage in which the pressure increases between the last-stage wheel and the condenser, thus causing a pressure less than condenser pressure at the last-stage wheel. Of such exhaust hoods it is often said that the loss is negative. Of course there can never be a "negative loss" in availability in any adiabatic process. The equation given above for the decrease in availability in a nozzle applies to this case as to all other cases where a change in kinetic energy is an essential part of the process.

THE BASE TEMPERATURE T_0

The computation of the function $b = h - T_0 s$ involves fixing on a sink temperature T_0. If the sink temperature is altered, all values of b, except those at $s = 0$, are altered. With them change the slopes of the constant-pressure lines and the distribution of availability losses for any one set of steam conditions. Thus any one b,s chart is suitable for only one sink temperature.

It is comforting to note, however, that a 10-deg change in sink temperature does not radically alter the diagram, and the correction for the change can readily be made. Below the b,s chart, Fig. 2, are given base lines for five different sink temperatures separated by 10-deg intervals. The middle and horizontal one, 50 F, is that for which the diagram was calculated. Changes in availability for a 50 F sink are obtained from the change in the ordinate of the chart or, what amounts to the same thing, from the change in distance from the 50-deg base line. Similarly, for any other sink temperature the change in availability is the change in vertical distance (parallel to the ordinate axis) from the corresponding base line. It can be seen that a satisfactory first approximation to losses from any process, with the exception of condensation, can be found directly from changes in ordinate on the chart given, and that more exact values for the proper sink temperature can be obtained without difficulty.

In computing b values for Fig. 2, 50 F was chosen as a base temperature because it closely approximates the year-round average of river temperatures and of wet-bulb temperatures for a large part of the industrial world. It is probably quite suitable for calculations for power plants in latitudes exceeding 35 deg.

The turbine designer might argue that the difference between the river temperature and the condensing temperature is determined by considerations foreign to the turbine, hence, as far as his turbine is concerned, the basis should be the condensation temperature. Perhaps he will not push this argument too far when he finds that the higher the T_0 used the lower will be the turbine effectiveness. There is, nevertheless, justice in the suggestion. Of two power plants taking circulating water from the same river, one may be condensing at 1 in. Hg abs (79 F) and the other at $1^1/_2$ in. Hg abs (91.8 F). The difference would be beyond the turbine designer's control, yet from the standpoint of the power-plant engineer each entire power plant should be studied from the river temperature as the sink temperature. But comparisons between the two turbines should be made using the condensation temperature of each as T_0 for the calculation of its respective effectiveness.

This becomes more obvious if the comparison is between a 400-lb-per-sq-in. turbine, exhausting to process at 50 lb per sq in. and a 400-lb-per-sq-in. turbine exhausting to a condenser at 1 in. abs. If the same sink temperature is used for both, the high-back-pressure turbine gets credit for a large reheat effect throughout, while the condensing turbine gets only the normal credit for reheat. Overall efficiencies have all the usual disadvantages in this case. In so far as a comparison can be made between two such turbines, it can best be made on the effectivenesses based on the respective condensation temperatures as T_0.

AVAILABILITY AND MARKETABILITY (COST ACCOUNTING)

The use of exhaust steam from engines for heating and process work has raised the question of the apportionment of steam-generating costs between power production and process or heating. The most common method is to debit the various devices with the enthalpy or total heat of the steam entering them, and credit them with the enthalpy of the steam or condensate leaving. A condensing turbine and its condenser are treated as a unit, and are consequently charged with practically all the enthalpy which enters the turbine. On the other hand, a turbine exhausting to process is ultimately charged with the change in enthalpy of the steam, which is equal to the work delivered by the turbine, and is only about 5 per cent of the enthalpy of the steam entering the turbine. The remaining 95 per cent is charged against the departments using the exhaust for heating or process.

That there are certain absurdities in this method is evident. For instance, if a low-pressure condensing turbine were at some time substituted for the process following this high-pressure turbine, it would be able to deliver an approximately equal amount of work with the high-pressure turbine. But unless we were to alter radically our accounting methods, the low-pressure-turbine power would be 95/5 or 19 times as expensive as the high-pressure-turbine power.

The accountant has a legitimate defense in that he has been using the usual method of computing the cost of a by-product, in this case power, when he charges to the by-product only those additional costs which are directly chargeable to its production.

There are doubtless many instances in industrial-power-plant engineering where it is wrong to consider power as a by-product of a process to which the engines are supplying exhaust. I shall not attempt to enumerate them or to analyze them. Suffice it to say that there are many indications in the current literature on economics of engineering of dissatisfaction with energy as a basis of cost-accounting methods.

A large business has been developed in New York City which consists entirely of selling Btu by the billion as heat for office buildings and apartment houses. Alongside the boiler plants operated for this purpose are power plants which every day send into the river as waste more Btu than the heating company could sell in weeks. The difference between these two energy supplies lies, first, in marketability, and, second, in thermodynamic availability, and it is not difficult to see that the economic property depends very largely on the thermodynamic property. A large availability means the ability to do useful work or to provide heat to substances at elevated temperatures, and it is such ability that is marketable.

The simplest accounting method based on availability would consist of debiting each manufacturing department or piece of apparatus with the availability (Σwb) of the streams of fluid delivered to it, and crediting each with the availability of the fluid streams returned to the boiler plant. If less fluid is returned than was delivered the credit will consist of the availability of the corresponding amount of make-up water in addition to the availability of condensate. The cost of a unit of availability will be determined from boiler-plant operating costs and fixed charges.

Selling price will depend on many factors besides the availability. It will particularly depend upon how soon power from an industrial power plant will rise from its status as a by-product to a new dignity as a joint product with process and heating. When and where it does this it will be charged, as process will be charged, for its share of the thermodynamic availability.

Appendix

DERIVATION OF FUNCTION *b*

THE FIXED-MASS (NON-CONTINUOUS FLOW) CASE

ASSUME a fixed mass of fluid at rest in state m, having pressure p_m, specific volume v_m, absolute temperature T_m, internal energy U_m, etc., in a container surrounded by an indefinitely large atmosphere at pressure p_0 and absolute temperature T_0, T_0 being generally less than T_m.[8]

Since the fluid is at a temperature different from that of the atmosphere, and at a pressure different from that of the atmosphere, heat can be made to flow from it and work can be done by or on it without using any sources of energy other than the fixed mass of fluid and the surrounding atmosphere. Also, heat flow may occur and work may be done until T_m is reduced to T_0, the temperature of the atmosphere, and p_m is reduced to p_0, the pressure of the atmosphere, when no further heat flow may occur and no further work may be done without using a new source of energy.

Let us define availability as the maximum amount of work which can be delivered to, say, an elastic spring (a work reservoir) operating in the atmosphere by virtue of a change in the condition of the gas in the container from condition m to condition 0, where its temperature and pressure are those of the atmosphere. Then the availability is the work which can be stored in the spring by a reversible heat engine which carries the fluid by reversible processes from m to 0.

That the work done by the reversible heat engine is the maximum can be proved by the usual reduction-to-absurdity method. Assume that there is an irreversible engine which will take our fixed mass of fluid at condition m and reduce it to condition 0 and deliver an amount of work greater than that turned out by the reversible engine. An appropriate amount of this work may now be used to take an equal amount of fluid at condition 0 and raise it to condition m in the reversible engine. The final condition of our fluid system is equivalent to the initial condition. By hypothesis there is an excess of work from our irreversible engine the energy corresponding to which ultimately could have been obtained only from the surrounding atmosphere. This, according to the second law, is impossible.

It remains, then, to find the work which could be delivered to our spring reservoir by a reversible engine taking the fluid mass from condition m to condition 0. We can accomplish the change by taking infinitesimal increments of heat out of the fluid mass and delivering them to Carnot engines the work from each of which, $\left[-\frac{T - T_0}{T}\,dQ \text{ per unit mass}\right]$, will be stored in our spring. The withdrawal of heat will cause a reversible change in the volume and pressure of the mass, which in turn can be made to do work on our spring. The amount of this work delivered to the spring per unit mass of fluid for each step in the heat withdrawal will be

$$(p - p_0)dv$$

where dv is the increase in volume of unit mass of the fluid. It is evident that any number of reversible paths from m to 0 may be followed by this method. As a single instance take constant-volume cooling to the entropy at 0 [during which $\int (p - p_0)\,dv$ is zero] followed by constant-entropy expansion [during which $-\int dQ\,(T - T_0)/T$ is zero] to p_0. For each complete path the work delivered to the spring per unit mass of fluid is the availability above p_0, T_0, and is therefore

$$-\int_m^0 \frac{T - T_0}{T}\,dQ + \int_m^0 (p - p_0)dv$$

$$= -\Delta Q\Big|_m^0 + T_0\Delta S\Big|_m^0 + \int_m^0 pdv - p_0\Delta v\Big|_m^0$$

But $\Delta U = \Delta Q - \Delta W$ from the first law,

$= \Delta Q - \int pdv$ for reversible changes.

Hence

$$\text{Availability} = -\Delta U\Big|_m^0 + T_0\Delta s\Big|_m^0 - p_0\Delta v\Big|_m^0$$

$$= (U_m - T_0 s_m + p_0 v_m) - (U_0 - T_0 s_0 + p_0 v_0)$$

The change in availability per unit mass with reference to surroundings at p_0, T_0 when the condition of the fluid is changed from m to n is thus:

$$(U_n - T_0 s_n + p_0 v_n) - (U_m - T_0 s_m + p_0 v_m)$$

The function $(U - T_0 s + p_0 v)$ is a point function or property of the fluid which may be used, as shown above, to determine the change in availability of a fixed mass of fluid at rest for any change in state of the fluid. It is not new, but may be found in thermodynamic discussions of equilibria dating sixty years back.[9]

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[8] In refrigeration T_m will often be less than T_0. The analysis applies nevertheless.

Darrieus arrives at the function $(U - T_0 s)$ for the fixed-mass case. The availability corresponding to Darrieus's function can only be delivered to a spring reservoir if the pressure of the surroundings is absolute zero. Perhaps the difficulty arises from considering all work done *by* the fluid as available energy. This is clearly not true in an atmosphere of finite pressure if available energy is to be considered as energy which is completely convertible into any other form of energy. Fortunately the two analyses give the same result for the continuous-flow case.

THE CONTINUOUS-FLOW CASE

Consider now, the case of a continuous, steady stream of fluid[10] passing section 1 at the entrance to a piece of apparatus and passing section 2 at the exit (Fig. 1). While passing through the apparatus each unit mass of the fluid changes from condition p_1, T_1, v_1, U_1, etc. to condition p_2, T_2, v_2, U_2, etc. Let us assume for the moment that kinetic energies and potential energies above the datum at sections 1 and 2 are negligible.

The availability of each unit of mass at section 1 with respect to an indefinite medium at p_0 and T_0 is now augmented by the amount of work which could be stored in our spring by virtue of the continuous flow, that is, the displacement work, $p_1 v_1$, less the work which must be expended on the atmosphere, $p_0 v_1$. This might be made more evident by removing the apparatus following section 1 and placing a piston at 1 with pressure p_0 exerted from outside and pressure p_1 from inside. Now, for each unit of mass which passes section 1 the amount of work $p_1 v_1$ is done on the piston, of which $(p_1 - p_0)v_1$ is available for storage in our spring. The unit mass is still at pressure p_1 and temperature T_1, and may be removed in an appropriate container and caused to do the usual amount of work,

$$\Delta(U - T_0 s + p_0 v)\Big|_0^1$$

before being reduced to equilibrium with its surroundings at p_0, T_0. Thus the availability of each unit mass of fluid passing section 1 is

$$\Delta\left[U - T_0 s + p_0 v + (p - p_0)v\right]_0^1$$

$$= \Delta\left[U + pv - T_0 s\right]_0^1 = \Delta\left[h - T_0 s\right]_0^1$$

where h is enthalpy or total heat and is, by definition, equal to $U + pv$.

The increase in availability between section 1 and section 2 is then

$$(h_2 - T_0 s_2) - (h_1 - T_0 s_1)$$

It should be noted that this result is valid regardless of the method by which the change in state occurs between 1 and 2. Work may be done on or by the fluid, heat may be added or removed, and the processes involved may be reversible or irreversible.

The function $(h - T_0 s)$, like the corresponding function for the fixed-mass case, is a point function or property of the fluid which may be used, as shown above, to determine the change in availability of a fluid in continuous flow for any change in state along the fluid stream. I have given it the symbol b.[11]

The essential difference between the fixed-mass case and the continuous-flow case is that the fixed-mass case involves in its function the pressure of the atmosphere, p_0, while the function for the continuous-flow case does not include p_0. The change in availability between sections 1 and 2 in the continuous-flow case would be the same regardless of the pressure of the atmosphere.

KINETIC ENERGY

In the preceding derivation for the continuous-flow case it was assumed for simplicity that kinetic energies and potential energies above the datum were negligible. There are, however, many cases where a change in kinetic energy is an essential part of a process (there are fewer cases where change in potential energy above the datum is important). It remains, then, to expand our expression for change in availability.

If the fluid at section 1 has a kinetic energy of $V_1^2/2g$ per pound, we may get additional work out of it while reducing it to rest at the final equilibrium state. Thus, before doing work $p_1 v_1$ on the piston mentioned above, the fluid can be passed through a reversible impulse turbine wheel, from which it can be made to emerge at an indefinitely small velocity. The work done on the turbine wheel will be $V_1^2/2g$ foot-pounds per pound of fluid, all of which may be delivered to our spring reservoir.

The availability at condition 1 is then

$$(h_1 - T_0 s_1 + V_1^2/2g) - (h_0 - T_0 s_0) = (b_1 + V_1^2/2g) - b_0$$

and at condition 2,

$$(h_2 - T_0 s_2 + V_2^2/2g) - (h_0 - T_0 s_0) = (b_2 + V_2^2/2g) - b_0$$

The change in availability between 1 and 2 is

$$(b_2 + V_2^2/2g) - (b_1 + V_1^2/2g)$$

POTENTIAL ENERGY ABOVE DATUM

The problem involving potential energy above the datum cannot be stated so simply. Suppose the fluid at section 1 has a potential energy above the lowest available datum of z foot-pounds per pound. To determine the effect of this potential energy on availability we must expand our definition of availability. Let us arbitrarily adopt the following definition: Availability is the maximum amount of work which can be delivered to an elastic-spring reservoir operating in the atmosphere by virtue of reducing the fluid in question to rest at pressure p_0 and temperature T_0 at the lowest available level (the level nearest the center of the earth). This level we shall choose as our datum plane for measuring potential energies z.

To determine the availability of the fluid at section 1 of our fluid stream we must add a new mechanism to those already mentioned. The fluid involved may now be put through any one of a variety of reversible devices, preferably after having done work on the impulse turbine and the piston mentioned above, designed to deliver work to the spring reservoir while lowering the fluid to the lowest available level, $z = 0$. That part of the gravitational force on a pound of the fluid which can be made to do work in our device is $(1 - v_1/v_a)$ pounds, where v_a is the specific volume of the gas constituting the atmosphere. The work which can be delivered to the spring is thus $z_1(1 - v_1/v_a)$.

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[9] For instance, J. W. Gibbs, Trans. Conn. Academy II, pp. 382–404, December, 1873. Also in "Collected Works of Willard Gibbs," vol. 1, p. 40.

[10] In this analysis continuous flow means that at the two sections considered the properties of the fluid, its velocity, and its potential energy above the datum are uniform and do not change with time, and that the mass rates of flow past these sections are equal.

[11] $b(= h - T_0 s)$ should not be confused with the much older characteristic function, $h - Ts$.

Our new expression for change in availability between 1 and 2 is

$$[b_2 + V_2^2/2g + z_2(1 - v_2/v_a)] - [b_1 + V_1^2/2g + z_1(1 - v_1/v_a)$$

It is obvious that this new addition to the availability of the fluid, $z(1 - v/v_a)$, is negative whenever $v > v_a$. In other words, work must be done *by* our spring reservoir in lowering the fluid from $z = z_1$ to $z = 0$ if the fluid is less dense than the atmosphere. If we were endeavoring to deliver the maximum possible amount of work to the spring we should, in the case of fluids less dense than air, permit the fluid to go to the highest available level instead of to the lowest. Thus we find an absurdity in the last definition of availability, which stipulated lowering to the lowest available level.

Fortunately, in engineering problems we find it unnecessary to resolve this dilemma. Our last definition of availability is satisfactory for use in the analysis of operations on dense fluids, like compressed liquid water, where changes in potential energy above the datum are large enough to assume importance. In the case of more compressible fluids, changes in potential energy are usually so small as compared with changes in the other quantities in the equation (b and $V^2/2g$) as to be negligible.

SUMMARY

Fixed Mass of Fluid at Rest:

- Change in availability while changing from state m to state $n = (U_n - T_0 s_n + p_0 v_n) - (U_m - T_0 s_m + p_0 v_m)$

Continuous Flow of a Fluid:

- Negligible change in kinetic energy and potential energy above datum:
  - Change in availability while passing from state 1 to state $2 = b_2 - b_1$ for one pound of fluid.
- Finite change in kinetic energies but negligible change in potential energy above datum:
  - Change in availability while passing from condition 1 to condition $2 = (b_2 + V_2^2/2g) - (b_1 + V_1^2/2g)$
- Finite change in kinetic energy and potential energy above datum for a fluid always denser than the surrounding atmosphere:
  - Change in availability while passing from condition 1 to condition 2

$$= [b_2 + V_2^2/2g + z_2(1 - v_2/v_a)] - [b_1 + V_1^2/2g + z_1(1 - v_1/v_a)]$$

Discussion

Ernest L. Robinson.[12] Fig. 8 shows the ratio between the Darrieus efficiency, which Professor Keenan so admirably names "effectiveness," and the ordinary efficiency ratio for a stage of a steam turbine. Fig. 9 shows the actual value of the Darrieus efficiency or "effectiveness" in comparison with the corresponding stage efficiency. These two diagrams are based on a "sink temperature" of 80 F, corresponding to the 1 in. Hg back pressure ordinarily specified for steam turbines in these latitudes. They permit ready interpretation between the accepted language of efficiency and the proposed language of effectiveness.

The analysis proposed is essentially an attempt to evaluate the convertibility of heat into power with due credit for its grade. It is useful to distinguish between high-grade and low-grade heat. However, in making any new evaluations of flowing heat, it will be necessary to keep in mind that the property to be evaluated may not always be its convertibility into power, and in each case the property which has marketable value is the one which should be evaluated. It is important to remember that, as Professor Keenan points out, there is nothing the matter with the idea of efficiency as now in use. As a matter of fact, the turbine designer fully appreciates the value of reheat which is so well exemplified by the "effectiveness" of a stage, while the purchaser of a turbine for the generation of power in a central station is interested only in the overall heat rate.

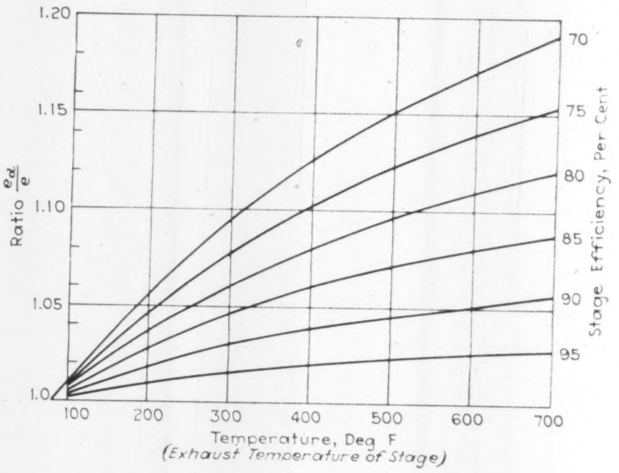

FIG. 8 RATIO OF DARRIEUS EFFICIENCY e_d TO STAGE EFFICIENCY e

$$\frac{e_d}{e} = \frac{1 + \left(\frac{1-e}{e}\right)}{1 + \left(\frac{1-e}{e}\right)\frac{T_0}{T}}; \quad T_0 = 540 \text{ F abs} = 80 \text{ F}$$

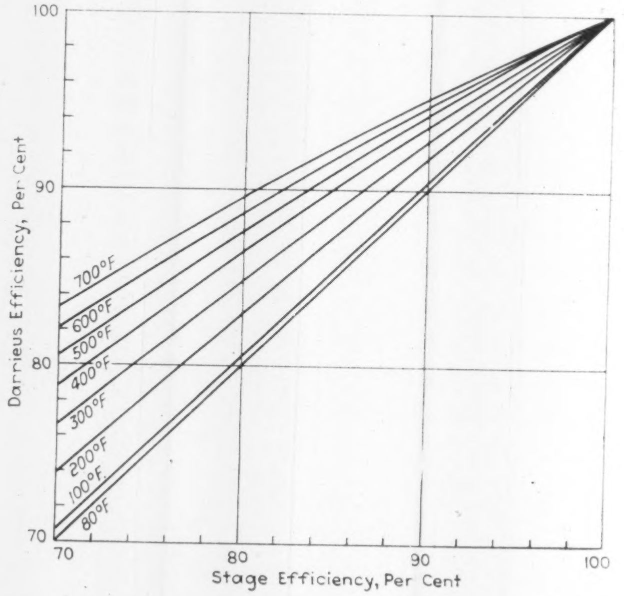

FIG. 9 RELATION BETWEEN DARRIEUS EFFICIENCY AND STAGE EFFICIENCY FOR VARIOUS STAGE EXHAUST TEMPERATURES

(See *Engineering* (London), Sept. 5, 1930; e_d/e and T_0 have the same values as in Fig. 8.)

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[12] Turbine Engineering Department, General Electric Co., Schenectady, N. Y. Mem. A.S.M.E.

ECONOMIC LOT SIZES

Derivation and Application of a Formula for the Determination of Economic Production Quantities

By G. L. STUDLEY[1]

IT IS THE purpose of this paper to encourage the use of mathematical formulas in the determination of economic production quantities. An attempt is made to explain the underlying theory in fairly simple terms and apply practical limits to some of the unnecessary refinements used in purely theoretical formulas. Professor Raymond's excellent paper on economic production quantities[2] has been of valuable assistance in this work, and it is felt that every effort should be made to arrive at a formula that can be used by the average production manager, who has neither time nor training to study through extensive mathematical theory. A general formula of this nature is necessarily complex, but when applied to a particular plant, many of the complications can be eliminated.

THEORY UNDERLYING THE GENERAL FORMULA

An economic production quantity is that quantity of goods whose total preparation cost (set-up, spoilage, etc.) is in mathematical balance with the total carrying charge. This can be best illustrated by a chart (Fig. 1) showing the ultimate cost of a unit of product.

As the lot size decreases to less than the economic quantity, the annual preparation cost increases, and of course the ultimate cost increases. If the lot size is increased and becomes greater than the economic quantity, the annual carrying charges are increased and the ultimate cost of the item is also increased.

It is obvious, then, that the ideal quantity of goods to be manufactured in one lot will have a total preparation cost equal to its total carrying charge, that is:

$$P = I$$

where P = annual preparation cost for any item, and
I = total annual investment and space charges for any item.

CONSTRUCTION OF THE GENERAL FORMULA

A general formula will be developed and explained in detail, with practical limits applicable to each element. It will be shown that this general formula, when applied to a particular plant, can be simplified to the form:

$$N = K\sqrt{A}$$

in which

N = economic number of lots to be processed per year
A = sales forecast or anticipated annual production of any item
K = a constant for any item or group of items having similar set-up and unit costs.

All of these terms are subsequently explained in detail.

TOTAL PREPARATION COST (P)

The total preparation cost for one lot is equal to $p + c + w$, that is, set-up cost (p), plus spoilage caused by setting up machines (c), plus the cost of placing a manufacturing order (w). Therefore the annual preparation cost (P) is equal to this quantity multiplied by the number of lots produced in a year, or:

$$P = (p + c + w)N$$

It is not considered proper to include an overhead rate on the indirect labor of set-up, nor on idle-machine time due to set-up. Theoretically, such rates should be included, but in practice the machines usually stand idle many hours in addition to the time required for set-up, and to charge idle time to the cost of set-up would be an unnecessary refinement.

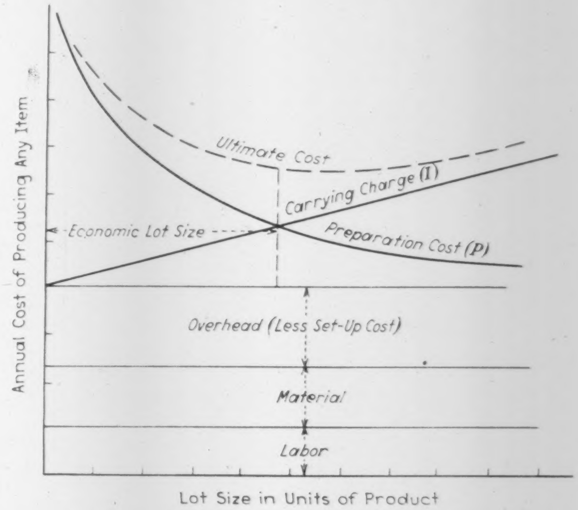

FIG. 1 CHART SHOWING ULTIMATE COST OF A UNIT OF PRODUCT

TOTAL CARRYING CHARGE (I)

The total carrying charge (I) is composed of three elements, interest on work in process (I_w), interest on finished goods (I_s) and a rental charge for space occupied by finished and in-process goods (I_f). All three of these elements are factors in determining the total carrying charge, but in most cases two of the elements can be eliminated from the calculations without causing a serious error in the resultant lot size. The element of cardinal importance depends upon the nature of the product and the annual sale of the item in question.

The Annual Investment Charge on work-in-process (I_w), assuming that lots are processed in continuous succession the entire year, may be expressed as follows:

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[1] Field Engineer, MacDonald Bros., Inc., Boston, Mass. Jun. A.S.M.E.

[2] "Economic Production Quantities," by Fairfield E. Raymond, Trans. A.S.M.E., vol. 49-50 (1927-1928), paper MAN-50-10.

$$I_w = \left(m + \frac{L}{2}\right) Ai \frac{1}{N}$$

in which

m = unit material cost for any item
L = unit labor cost plus overhead for any item
i = interest rate on borrowed or invested funds, depending on the company's financial policy.

The factor $(m + L/2)$ is the average unit cost, under the assumption that labor and overhead are added to the product at a uniform rate, which is sufficiently accurate for practical purposes in most manufacturing plants. Multiplying the average unit cost of an item while in process $(m + L/2)$ by the annual production (A) of that item and dividing by the number of lots to be produced (N), gives the average value of one lot. The average value of one lot multiplied by the annual interest rate (i) gives the annual investment charge applicable to the goods while in process.

The Annual Investment Charge on Finished Goods (I_s), assuming that each lot requires an entire year to be disbursed from finished stores, is expressed by the formula:

$$I_s = \left(\frac{m + L}{2}\right) Ai \frac{1}{N}$$

Theoretically, the condition named applies only to items produced at intervals of more than one year, but in practice this element is of major importance in computing lot sizes for items having a small annual sale. The factor $[(m + L)/2]$ is the average unit cost under the assumption that goods are withdrawn from stores at a uniform rate, which is sufficiently accurate for all practical purposes. It is true that very few concerns are fortunate enough to have an absolutely flat sales curve, but it is felt that the use of a formula involving a variable consumption rate, and consequently a variable lot size, is an unnecessary refinement.

The average value of one lot is the average unit cost $[(m + L)/2]$ multiplied by the annual production (A) to give annual cost of the item, and the product of these factors divided by the number of lots (N) processed per year. This average value of one lot multiplied by the annual interest rate (i) gives the annual investment charge on one lot while held in finished stores.

The Annual Space Charge on Finished and In-Process Goods (I_f), assuming each lot to remain in the plant an entire year, may be expressed by the formula:

$$I_f = \frac{F}{2} A \frac{1}{N}$$

The factor $F/2$ in which F = annual charges for storage space per unit of product, is the average annual space charge under the assumption that the production and consumption of goods are at a uniform rate. The product of this factor and A divided by N results in the annual space charge per lot.

DETERMINATION OF N

It has been stated that the annual preparation cost (P) should be equal to the annual carrying charge (I) for any item if the product is to be produced in economic quantities. Therefore P must equal the sum of some functions of the three carrying-charge elements I_w, I_s, and I_f, the relationship depending on the time in process and the time in finished stores. In nearly every plant two of these elements can be eliminated and the total carrying charge represented with reasonable accuracy by the remaining element. For instance, the space charge would be of major importance in a furniture plant, but would be of no practical importance whatever in a watch factory. Also every plant has certain products that are in process of manufacture nearly all the time, while certain other products are produced only once or twice a year.

A concrete example will be used to illustrate just how the carrying-charge elements of least importance can be eliminated. Before going into this phase of the problem it is considered advisable, for the sake of clearness, to obtain the solution for N, using only one of the carrying-charge elements in the solution.

Using the work-in-process element of the carrying charge as the controlling factor, the solution for N is as follows:

$$P = I_w$$

$$(p + c + u)N = \left(m + \frac{L}{2}\right) Ai \frac{1}{N}$$

$$N = \sqrt{\frac{\left(m + \frac{L}{2}\right) Ai}{p + c + u}} = \sqrt{\frac{\left(m + \frac{L}{2}\right) i}{p + c + u}} \sqrt{A}$$

Let

$$K_w = \sqrt{\frac{\left(m + \frac{L}{2}\right) i}{p + c + u}}$$ = a constant for any item or group of items having similar set-up and unit costs

then

$$N = K_w \sqrt{A}$$

The same theory underlies the solution when the finished-stores element or space element is the controlling factor. The constants then arrived at would be called K_s and K_f.

With the annual production (A) and economic number of lots (N) as known or estimated values, the economic production quantity (Q) is determined as follows: $Q = A/N$.

SIMPLIFICATION OF FORMULA WHEN APPLIED TO A PARTICULAR PLANT

A method of arriving at the carrying-charge element or elements that should be used for a given plant can best be explained by an illustration. Assume that the problem is to compute economic lot sizes for a plant manufacturing plated tableware and that the average time in process is ten weeks.

Storage-Space Element. In a plant of this type, the charge accruing from storage of any item is insignificant. Approximately $1500 worth of tableware can be stored on a square foot of floor space at a rental charge of about 35 cents a year. When this charge is divided by the number of lots processed per year, the rent expense per item becomes a negligible factor.

Elements for Work-in-Process and Finished Goods. Elimination of the rental element reduces the carrying charge to two factors, i.e., interest on work-in-process and interest on finished goods. The relative importance of these two factors varies with the number of lots produced per year, and since the production quantity varies as the square root of the carrying charge, the formula can be further simplified by eliminating one or the other of the investment elements without seriously affecting the resultant lot size.

The average time in process in the tableware plant in question was considered to be ten weeks. Items having small annual sales presumably would be made in one lot per year or less; therefore the annual time in process for such items would be ten weeks, while the time in finished stores would be fifty-two minus ten, or forty-two weeks. In this case the interest on finished goods is the element of major importance.

Items having large annual sales would be manufactured in a comparatively large number of lots, say, twenty-four per year, which means that lots would be put into production at about two-week intervals. It is evident that one or more lots would be in process the entire year, as the consumption rate per lot (2 weeks) is five times as great as the production rate (10 weeks). In this case the work-in-process element is by far the most important.

The relative importance of the two investment elements can be determined by index ratios R_w and R_s, worked out in the following manner:

$$R_w = \frac{I_w}{I_w + I_s} \qquad R_s = \frac{I_s}{I_w + I_s}$$

Since the space element has been eliminated, $I_w + I_s$ is considered to be the total carrying charge. Then

$$I_w = T_w\left(m + \frac{L}{2}\right)Ai$$

This equation indicates that the annual interest charge accruing from work in process is dependent upon T_w, the fractional part of a year that the item is in process. In the tableware plant, T_w is equal to ten weeks divided by fifty-two weeks when goods are produced in one lot. Also

$$I_s = T_s\left(\frac{m + L}{2}\right)Ai$$

where $T_s = (52 - 10)/52$.

Selection of the Controlling Element for a given group of items. For example, assume the approximate factory cost of any group of similar items as:

Unit material (m)	\$35.00
Unit labor plus overhead (L)	65.00

Substituting in the formulas:

$$I_w = T_w\,[35 + (65/2)] \qquad Ai = T_w\,(67.5)\,Ai$$

$$I_s = T_s\,[(35 + 65/2)] \qquad Ai = T_s\,(50.0)\,Ai$$

Since the object of the calculation is to determine a ratio for a given group, the factors A and i are constants and can be omitted.

EXAMPLE 1—When $N = 1$

$$I = I_w + I_s$$

$$= \left(\frac{10 \text{ weeks}}{52 \text{ weeks}} \times 67.5\right) + \left(\frac{52 - 10 \text{ weeks}}{52 \text{ weeks}} \times 50.0\right)$$

$$= 12.96 + 40.40 = 53.36$$

$$R_w = \frac{12.96}{53.36} = 0.243 \qquad R_s = \frac{40.40}{53.36} = 0.757$$

The above solution shows that by using the value for interest charges on *finished goods only*, the resultant carrying charge will be reduced by 24 per cent; but since the lot size varies as the square root of the carrying charge, the calculated lot size is within approximately 5 per cent of the true economic quantity.

EXAMPLE 2—When $N = 4$

$$I = I_w + I_s$$

$$= \left(\frac{4 \times 10 \text{ weeks}}{52 \text{ weeks}} \times 67.5\right) + \left(\frac{52 - 40 \text{ weeks}}{52 \text{ weeks}} \times 50\right)$$

$$= 51.91 + 11.55 = 63.46$$

$$R_w = \frac{51.91}{63.46} = 0.818 \qquad R_s = \frac{11.55}{63.46} = 0.182$$

This shows that by using the value for interest charges on *work in process only*, the resultant carrying charge will be reduced by 18 per cent but the calculated lot size will be within approximately 4.2 per cent of the true quantity.

The chart shown in Fig. 2 indicates that tableware items being processed in two lots or less per year will use the finished-stores element only, while items being processed in more than two lots per year will use the work-in-process element only. It is true that items processed in the neighborhood of two lots per year will have a maximum error in lot size of about 7 per cent. An error of this magnitude is not felt to be objectionable in any plant, for two reasons: First, raw material is usually purchased in quantities of a certain number of tons, bundles, carloads, or tank-carloads, and in practice the lot size will be made to conform to the nearest raw-material unit. Secondly, the error due to the simplification of the carrying charge tends to increase the lot size slightly, and, as can be seen from Fig. 1, a slight increase in lot size does not affect the ultimate unit cost appreciably. An error tending to decrease the lot size below the economic quantity would be a far more serious matter.

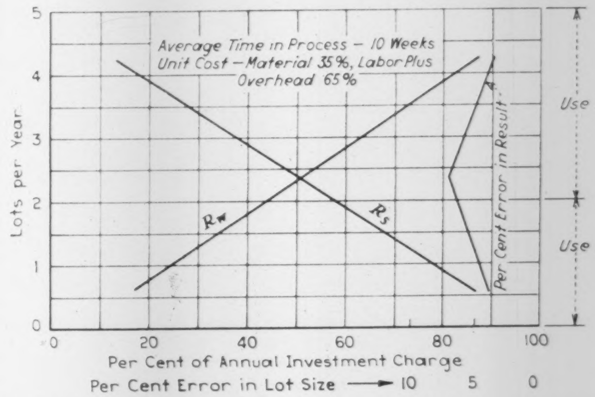

FIG. 2 GRAPH SHOWING RELATIVE IMPORTANCE OF INVESTMENT ELEMENTS IN FORMULA FOR ECONOMIC PRODUCTION QUANTITIES
(Flatware—Group 1. Average time in process, 10 weeks. Unit cost: Material, 35 per cent; Labor plus Overhead, 65 per cent.)

GENERAL

The amount of clerical effort required for calculation of the various constants K_w, K_s and in some industries K_f, depends upon the extent to which grouping of similar items is possible. The work of compiling a table of constants for a plant manufacturing approximately 6000 items will require the time of a capable cost clerk for about a month, and should be closely supervised by an engineer who understands the formula. The constants do not require correction more than once a year unless there is an appreciable change in unit cost of the product or a radical change in process involving set-up and spoilage.

With the table of constants computed and the sales forecast available, the calculation of economic lot sizes is a simple slide-rule operation. The calculation is first made using K_w, and the resulting value of N will indicate whether or not it is neccessary to recalculate, using K_s or K_f, as the case may be.

MECHANICAL ENGINEERING

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GEORGE A. STETSON, *Editor*

Increased Use of Library

DURING 1931 the Engineering Societies Library in New York served 27,943 readers, the largest number ever recorded, according to the report of the director, Harrison W. Craver. It will instantly be supposed that the increase in the use of the library may be attributed to the fact that many engineers out of work find time for study. Mr. Craver points out, however, that while the unemployment situation is undoubtedly a factor, the increase has resulted rather from a growing appreciation of the wealth of information readily accessible in the library's collections.

In support of this explanation it is of interest to note that the Christmas holidays brought an unusually large number of persons to the library. From all indications, this increase of readers represented students and instructors who made use of the opportunity which the holidays and a visit to New York afforded to do some work in the library. It is becoming increasingly evident that the library is on the lists of visits to be made in New York by engineers from out of town.

These and other engineers should not forget that through its search, translation, and photostat departments the library is organized to serve those who cannot visit it in person. For example, any paper, abstracted in the Survey Section of MECHANICAL ENGINEERING or noted in the Engineering Index items every month, may be obtained in photostat form from the library.

Engineering and Men

IN A RELEASE by the Education Research Committee of the Engineering Foundation there are reported the results from a group of letters obtained by Dr. Alexander R. Stevenson, of the General Electric Company and a member of the Committee, from twenty-eight young men in his company ranging in service since graduation from six months to five years.

The practically unanimous reactions of these young engineers indicate that they are not disappointed in their choice of a profession, and can recommend it to others truly interested and properly equipped by education and training. With few exceptions, administrative positions are looked upon as the goals toward which they are striving. Looking back at their educational requirements, they place greatest stress on subjects of a theoretical character, particularly those that assist in learning to think. Mathematics through differential equations, physics, mechanics, English, public speaking, economics, and a sprinkling of "cultural" and business courses are specifically mentioned.

Here, in a modest way, is an endorsement of present tendencies in engineering education by men who represent some twenty educational institutions. This should be gratifying to those who are responsible for these tendencies.

The younger brothers of these men, who are still at school, will do well to ponder the implication in the replies, which is that proficiency in theoretical studies that teach men to think and give them a broad knowledge of technical matters, liberalized by a certain familiarity with cultural and non-technical subjects, is the best training for an ultimate administrative position that must be approached by means of an engineering career. Inevitably the successful mechanical engineer must deal with technology and with men, and his education must contain those elements that fit him to understand the ways of both.

Finding Work for Engineers

SINCE October, 1931, the Professional Engineers' Committee on Unemployment has been operating in the New York district. Its work was quickly and effectively organized under the leadership of H. deB. Parsons, general chairman, and J. P. H. Perry, chairman of the executive committee, and has been carried forward with a vigor commensurate with the urgency for immediate action. Money is being raised, men registered and interviewed, jobs canvassed, work found or "made," funds distributed, contacts established with similar organizations, local and national, and advice and legal assistance provided where necessary.

The work of the Committee, with statistics covering the period up to the middle of January, 1932, was described in the February, 1932, issue of *Civil Engineering*. The description includes the Committee's organization chart and the details of the system of relief. Other engineering communities that are carrying out similar relief work or are contemplating undertaking such work may obtain reprints of the article describing the work of the New York Committee by addressing their requests to the Professional Engineers' Committee on Unemployment, 29 West 39th Street, New York City.

In their admiration of the splendid organization which this and other committees have set up and their effective service, engineers must not lose sight of the fact that jobs and funds are urgently needed. The present situation, in which so many engineers are not only out of work but in some cases are facing destitution, is an unprecedented one. It is a time when professional solidarity can be demonstrated in very practical terms by those who are able to do so. Let it not be said of engineers that they are heedless of their own or unable to help them. Those who can do so should provide jobs, or money, or both.

Chemical Engineering Graduates

ENGINEERS who followed the report on the "1930 Earnings of Mechanical Engineers" which appeared serially in the September, November, and December, 1931, issues of MECHANICAL ENGINEERING, will be interested in the report on "Occupations and Earnings of Chemical Engineering Graduates," by Prof. Alfred H. White, which appeared in *Industrial and Engineering Chemistry* for February, 1932. The fact that the first-mentioned report, which was based upon statistics furnished by members of The American Society of Mechanical Engineers, indicated that seven per cent of those replying to the questionnaire were engaged in the chemical manufacturing industries, including oil, mining, and metallurgical, as well as the strictly chemical industries, affords a further bond of interest for the two reports. Mechanical engineers in those chemical manufacturing industries, as shown by the chart on page 878 of the December section of the report, have salary characteristics slightly more favorable than those of the entire mechanical engineering profession during the first ten years out of college, which is the period covered by Professor White's report, and apparently chemical engineering graduates do at least as well if not better.

The A.S.M.E. report aimed at presenting a picture of the status of the mechanical engineering profession, while Professor White's object was more specifically to assist in the formulation of a curriculum in chemical engineering by a study of the work that recent graduates had been engaged in. Thus Professor White's report covers a period which the A.S.M.E. figures show to be one of preparation for a man's life work, and one in which the differences in rates of earnings of various groups are relatively small on that account.

It would appear that 60 per cent of the graduates in chemical engineering out of college 10 years are to be found in research, plant development and operation, and general engineering. As would be expected by one who has studied the A.S.M.E. report, the poorest paid groups of chemical engineering graduates are teachers and those in analytical laboratories. Men with graduate training have a pronounced advantage in earning power over those without it, when they are 10 years out of college. This was not found to be true in the A.S.M.E. study of men of corresponding age.

One of the striking features of the A.S.M.E. report was the marked difference in the earnings of engineers with managerial and non-managerial functions. Positions involving executive responsibility were shown to be recompensed with higher salaries. Professor White's report was based on men too young, in general, to have attained executive positions, defining the executive as a general officer of a corporation. Defining an executive as one who guides and directs others in important projects, there is abundant evidence, says the report, that many, even of those out of college only a few years, are in executive positions. "A questionnaire sent to these same men after another decade," concludes Professor White, "would undoubtedly show a much larger proportion as general officers of corporations, for there is an evident trend in industry to recruit the higher administrative staff from the ranks of men with professional training." Abundant evidence exists of the soundness of Professor White's statement, for it has been found to be so in other industries into which professional engineers have made their way. The world needs trained engineers with broad human sympathies to handle the complicated affairs of industrial progress.

The Volume of Business and the Color of Ink

THERE is a joke current among accountants that the industry of red-ink making is booming because of their demand for that fluid, with which to enter figures in the loss column.

Illuminating material as to why so much red ink may thus be consumed is supplied by a publication issued from the headquarters of the National Association of Manufacturers under the title, "Profits Versus Competition." The important conclusion at which the publication arrives is, essentially, though not stated in just these words, that in going after business a concern may, and not infrequently does, reach a point where instead of making money it begins to lose money. In other words, we are dealing here with an application to general business of the Boehm-Bawerk theory of marginal returns, familiar enough to economists, but apparently too gloomy for adoption by enthusiastic business men.

It is generally acknowledged today that the cost of distributing and merchandising manufactured products is rising. The impression is that the distribution of a product costs as much as, and in some instances more than, its actual fabrication. From the trend indicated by available data, one may state as an approximation that at least 30 per cent of the consumer's purchasing dollar is spent on distribution, and that this proportion is increasing markedly from year to year. This increase in cost falls chiefly under two headings, namely, cost of salesmen and cost of advertising, and it must be clearly understood that expenditures on these instrumentalities of distribution are as vital to a business as fire insurance.

As the National Association of Manufacturers states, the manufacturer whose product is backed by extensive advertising is enabled to get business away from the competitor whose product is not so well advertised, even though their two products are identical in every respect. It is therefore evident that the increased cost of selling for some manufacturers is not due to poor judgment or lax effort, but to the changing nature and greater intensity of competition. There is competition that favors progress and competition that hinders it, but no matter what its character, it brings about a rising cost of distribution.

The following conclusions are cited verbatim, and are well worth attention because of the representative character of the body from which they emanate.

"This increasing intensity of competition includes elements which do not favor, and are even unnecessary to, a maximum degree of progress.

"The increasing intensity of competition has made existence precarious and profits low or negligible to great numbers of manufacturers and distributers in spite of increased skill and effectiveness in many directions. Unrestrained competition is therefore against the best interests of manufacturers and distributers.

"The increasing intensity of competition in many industries, appearing in excessive selling costs, has diluted the value of productive labor so that the return to production in the form of wages to workers and profits to management, is diminished by approximately the amount of this wasted effort. Unrestrained competition, therefore, is against the best interests of both workers and management.

"The increasing intensity of competition in many industries has resulted in a ruinous price level which has eliminated many concerns and thereby affected the purchasing power of whole communities. Unrestrained competition is therefore against the best interests of the consumers."

It is truly a crazy world where 30 cents out of every dollar is spent to get the consumer to buy goods which he presumably needs.

Statistical Methods in Strength Estimation

WHAT happens when we are pulling apart, say, a $^1/_4$-in. round steel rod in a testing machine? In answering this question we might imagine that we are dealing not with a solid rod $^1/_4$ in. in diameter but with a bunch of tightly held very fine wires, each, say, $^1/_{100,000}$ in. in diameter, and all parallel to each other. In such a wire rope not all the wires will be equally strong. Some may be perfect, others may have surface flaws acting as notches, and still others may have been improperly drawn and as a consequence have hollow spaces inside, greatly weakening their strength; and there may be wires that carry inclusions, such as tiny particles of slag, which again greatly weaken their strength. As the stress is applied, the weakest wire will be the first one to snap. When this happens, it ceases to carry its share of the load and more stress is thrown on the remaining wires. This produces a rupture of the next weakest wire or group of wires, which in turn throws more load on the remaining individual wires. Gradually the non-perfect wires are all broken and the load is thrown on the remaining perfect wires. The load per wire is now very much greater than it was at the beginning, because only a portion of the wires are carrying it, and there finally comes a moment when the perfect wires cannot withstand the stress, and all break at the same or substantially the same time.

Still assuming that our rod has been replaced by a rope consisting of extremely fine parallel wires, we have to remember that, in the final count, the ultimate strength of such a rope depends on the proportion between the perfect and the defective wires.

It is merely a matter of what might be called an accident that one of these wires has a surface flaw, another an inside cavity, a third an inclusion of a bit of slag or a gas pocket, etc. When we replace each individual wire by a string of atoms located along the direction of the stress, we shall probably also find that such strings may contain imperfections the nature of which we do not know, but which weaken the ability of the strings to withstand stresses. As in the case of the wires, the presence of these weakening elements in each particular string of atoms is what might be termed accidental, and yet it is found that a number of pieces of steel produced by the same method show approximately the same characteristics when subjected to certain stresses (which is what makes specifications of materials possible).

In the case of a wire rope such as that described above, this would mean that the proportion between the defective and perfect wires in a rope produced by a certain method is substantially the same, which, in turn, would mean that while no individual wire can be said to contain of necessity a weakening factor or be of necessity free from one, nevertheless the usual statistical laws such as are expressed broadly in the so-called theory of probabilities apply and determine the ratio of perfect to imperfect wires. If we change the process of manufacture of the piece, its composition, or its previous history, we may change this ratio of perfect to imperfect wires or strings of atoms, but here again, while the numerical constants have been changed, the application of the statistical laws has not, and a chrome-nickel wire produced by a certain method may be stronger than a plain carbon wire, but all chrome-nickel groups of wires produced by that particular method will be substantially equally strong.

Life-insurance premiums are based on the workings of actuarial laws, and the insurance companies would soon cease business should these laws fail to work. Now, apparently, approximately the same thing happens in the case of the imaginary rope by which we have replaced the steel rod under test. A certain predeterminable, though not yet predetermined, number of wires break under the application of, say, the first 1000 lb, and this is indicated by the elongation which takes place in the rope under that load. A certain further number break with the next 1000 lb, and so on. We do not know and we cannot predict which of the wires will break first, just as we do not know which person among a thousand men forty-five years old will die first. We do know, though, how many of them are marked for demise each year, and if we possessed the information that would let us apply actuarial laws to the case of steel pieces, we could predict from the knowledge of certain factors the stresses which each piece is capable of withstanding.

The statistical methods involving what is now known as the principle of indeterminacy have been applied with striking success in quantum mechanics by Heisenberg and his followers, and unquestionably will soon be used in engineering.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

THE PORTLAND-CEMENT INDUSTRY

A Comparative Study of the Industry in the United States, Canada, and the United Kingdom

THIS is a very lengthy serial article and cannot be abstracted extensively because of lack of space. Therefore the parts reported here are those dealing with features which more especially concern the United States.

GENERAL CONSIDERATIONS

The development of the portland-cement industry in the United States was primarily affected by the disposition of the raw materials, which determined the choice between the wet and the dry processes. The early cement was made from cement rock found in the Lehigh district of Pennsylvania. With this material the dry process was the most economical. With the very great increase in demand for cement, hard limestone has superseded the use of cement rock and is now the most widely used raw material. Because of the change in material the wet process gradually gained ground, and in 1927, of 153 plants, $77^1/_2$ were employing the wet process and $75^1/_2$ the dry process. However, while 66 per cent of the total of all cement produced was made on the dry process and only the remaining 34 per cent on the wet process, there is nevertheless a steady trend toward the wet process. The selection of the process affects also the use of the waste-heat boiler. With the dry process the average temperature of the exhaust gases is about 1200 F compared with 600 to 700 F with the wet process, and with "atomized" or "spray-fed" slurry only about 300 F. In 1929 in the United States approximately one of every three cement plants had a waste-heat-boiler installation.

The original article gives statistical data for the capacity of portland-cement plants, volume of production, value of product, exports, imports, and consumption. In the United States the ratio of production to capacity has steadily decreased from 76.3 per cent in 1927 to 66.1 per cent for the twelve months ended March 31, 1930, but the total capacity of the plants was increased in 1928 by 1.63 per cent and in 1929 by 5.8 per cent. If the capacity of the mills had not been increased in 1929 the ratio of production to capacity at the end of that year would have been 70 per cent as against 66.1 per cent. This leads the author to the conclusion that in the United States new plants have been erected irrespective of whether or not the increase in the total capacity will benefit the industry as a whole, with the result that the industry is and has been for some years suffering from a redundancy of capacity. If the present rate of fall of ratio of production to capacity is allowed to go on, the ratio will be reduced to 50 per cent in five years. The author believes that it should be possible to maintain a ratio of at least 80 per cent as a minimum, while still providing for all fluctuations in home and foreign markets. At present in the United States there is an excess of capacity of at least 45 million barrels per annum, representing about $100,000,000 of capital. The interest on this capital at 5 per cent amounts to $5,000,000 per annum, and this amount, spread over the 170 million barrels of cement sold in 1929, is equivalent to 3 cents per barrel. In addition, depreciation of plant at 7.5 per cent per annum amounts to $7,500,000 per annum, or $4^1/_2$ cents per barrel sold, making a total of $7^1/_2$ cents per barrel.

RAW MATERIALS

Generally speaking, in the three countries under consideration most of the geological periods are represented, but there are certain raw materials used in the manufacture of portland cement in one or more of the countries which are not employed in the others. The most important of these is the Trenton limestone (cement rock), which is extensively used both in the United States and Canada but not in the United Kingdom. The Liassic formation of the Jurassic period is employed in the United Kingdom, but not apparently in the United States or Canada; but in the latter country there is in Vancouver Island a formation believed to be of the Lower Jurassic period, but which has physical characteristics different from the Liassic formation in the United Kingdom.

Generally speaking, the majority of materials used in the United States are hard and require crushing and grinding previous to burning in the kilns. The quarrying of the hard materials in the United States and Canada necessitates drilling and blasting as a preliminary to their being gathered by mechanical diggers, whereas in the United Kingdom the soft chalks and marls can in nearly every case be gathered by mechanical diggers direct from the face. The conveying of the softer material is also easier and cheaper.

In the United States there is a tendency to erect the plant near the market and bring the raw materials to it, particularly where limestone can be brought by water, as in recently built plants at Detroit and Buffalo. The limestone for these plants is screenings from a furnace flux and is brought by lake in self-unloading steamers. In the case of the Buffalo mill this distance is over 400 miles. The mining methods do not appear to be very different in the three countries considered, apart from such changes as are introduced by the difference in the materials themselves. The same essentially applies to the preparation of the materials, the methods being described in detail in the original article. This part cannot be abstracted because of lack of space.

Brief reference is made to the storage of raw materials. The percentage of water in the various raw materials depends entirely on their character, the minimum generally being found in hard limestones free from clayey matter and the maximum in clays. As the majority of the raw materials in the United States are hard, the matter of their moisture content has had an important bearing on the method of treatment and the choice of plants as compared with the United Kingdom and

Canada. Hard limestones contain from $^1/_2$ to 3 per cent of moisture, and in special cases with dry process and adequate protection from the water during handling, may be sent to the grinding mills without drying. Chalks and clays have to be dried

For final mixing in the United States the centrifugal pump is most generally used in pumping the slurry, but the air lift is also employed. In the United Kingdom a centrifugal pump is rarely seen on slurry service, the plunger type being almost universally used. The author considers the centrifugal pump preferable to the plunger pump.

It is a common experience with the movement of slurry in pipe lines to have trouble with the valves or cocks. On many pipe lines the valves do not have to be moved often for considerable periods, and even with valves that are in frequent use the solids in the slurry get between the faces and cause sticking. This may frequently require the dismantling of the valve, with consequent waste of time and delay. To overcome this source of trouble, a special lubricated valve has been designed, and has been in use in some works for a number of years. In this valve, which is of the plug-cock type, there is a tapped hole containing a check valve in the shank of the plug, and continued from this is a duct drilled outward to the surface of the plug and communicating with two grooves, one on each side of the plug, terminating in a chamber at the bottom of the plug. As the plug is arranged to rotate only a quarter-turn, the grooves on the bearing surface of the plug are never exposed to the liquid flowing through the pipe line. In operation the lubricant, in the form of a stick, is inserted into the neck of the plug, and, in being forced down by the screw, lubricant pressure is transmitted down the grooves into the base chamber. The result is that the plug is lifted and a lubrication film is obtained between the working faces of the plug cock. If the valve is difficult to move, the lubricant screw is given a slight turn, which not only forces the plug but supplies the whole of the bearing surfaces with the lubricant In the United States this valve is called the Nordstrom valve, while in the United Kingdom it is known as the Audco valve.

It is in slurry mixing and storing methods that practice in the United States and the United Kingdom differs. In the former country the mixer almost invariably takes the form of a traveling-bridge agitator, while in the United Kingdom the use of the "sun and planet" mixer is universal.

The details of the bridge and "sun and planet" mixers are given in the original article. An improved type of air-agitated slurry mixer recently introduced in the United Kingdom takes the form of a circular tank in which a lattice-girder arm is arranged to rotate, with its pivot at the center and its extremity on the side of the tank. On this girder arm are mounted a number of vertical air-supply pipes which reach nearly to the bottom of the tank, where they are curved backward. The arrangement is very light and takes but 6 hp for a tank containing 750 tons of slurry. The air pressure used is 10 lb per sq in.

THE KILN

The kiln is probably more capable of improvement than any other cement-making plant. The most important direction for improvement is in the more complete combustion of the fuel, whether it be coal, gas, or oil. Improvements in this direction when burning coal have been the finer pulverization of the coal and the greater regularity of its supply to the kiln due to improved pulverizing units, which the author proceeds to discuss.

Another improvement affecting combustion is the increased control of the feed of fuel into the kiln and the air necessary for proper combustion. The modern trend in kilns is toward the combined kiln and cooler unit.

The principal advantage of the combined kiln and cooler unit over the separate kiln and cooler is the very important one of the added control over the quantity of incoming air which is made possible by the former unit. In the separate type the air for combustion is a variable quantity over which very little control can be exercised. This air enters through the open end of the cooler, an unrestricted area up to about 100 sq ft, exposed to all fluctuations of atmospheric disturbance; it enters also in varying quantities through the joint between the feed end of the cooler and the clinker chute, as well as through the joint between the firing end of the kiln and the kiln hood. Neither of these joints can be other than a very poor air joint, as in both cases the joint has to be made between a revolving and a fixed object under conditions where a high degree of heat obtains.

With the combined kiln and cooler unit, the entering air, instead of coming in at one large opening with a low efficiency of heat exchange from clinker to air, is divided into a number of streams according to the number of cooling cylinders. This increases the rate of heat exchange by reason of the closer and more frequent contact between the air and the clinker. Further, the whole of this air must pass along the length of the individual cylinders, as there are no open joints between the inset end and the kiln. With this type of cooler the control of the quantity of air within close limits is not difficult, and, because of the disposition of the cylinders, fluctuations of pressure due to atmospheric disturbance are reduced to a minimum.

Structurally the combined kiln and cooler unit is simpler and cheaper than the separate type. The application of roller bearings to kilns is discussed next, and the author mentions a plant in the Lehigh Valley area where kilns 135 ft in length and completely equipped with roller bearings are giving satisfaction and have enabled a considerable saving of power to be effected. Another installation to which he refers is in Illinois.

SLURRY FEEDING

The usual method of feeding slurry into the kiln is by gravity. The gravity method has two distinct and inherent limitations; the first is that, by allowing all the added water to go into the kiln, it imposes the wholly unnecessary duty on the kiln of evaporating this added water; and the second, that the slurry stream cannot be broken up adequately, with the result that the transfer of heat from the kiln gases to the slurry is at a low rate, necessitating either a decreased rate of travel of the material through the kiln or an increase of heat at the same rate of travel. Because of these limitations more fuel has to be burned in the kiln than is necessary, and the efficiency is lowered.

To overcome the first limitation, slurry filters have been brought into extensive use in the United States. There are no filters on slurry feed in Canada or the United Kingdom. Of the two types of filters—the disk and drum types—filters for dewatering slurry duty are always of the former type.

The "spray feed" is a system which aims at increasing the rate of heat exchange from the kiln gas to the slurry by making use of the fact that the greater the surface of contact between a liquid and a gas of different temperatures, the greater the rate of heat exchange. In this system the slurry is introduced into the kiln in the form of fine spray, and it is claimed that an increase in exposed surface as high as 300-fold is obtained. The spray running counterflow to the direction of the kiln gases washes the gas, and before the particles fall to the bottom of the kiln they are sufficiently dry to have lost their tendency to ball together. (With the gravity system the material is fed into the kiln in a stream and is apt, particularly if the materials are colloidal, to form either balls of material or slurry rings in the kiln, thus reducing the rapid transfers of heat from the gases to the materials.)

In practice, atomizing of the slurry is effected by two or three nozzles arranged to spray into the cool end of the kiln at slightly different angles. Slurry containing the normal amount of water is delivered under pressure to the atomizing nozzles. Thirteen plants operate with this system in various parts of the world, one having been installed in the United States late in 1930.

WASTE-HEAT INSTALLATIONS

The only reason for such installations is economy. There are two methods by which this problem has been tackled successfully, methods which are diametrically opposed to each other. One method is to keep the heat of the exit gases at a minimum, or even artificially to increase it to suit the conditions demanded by a waste-heat-boiler installation and to transform as much as possible of such heat into useful work, and the other to reduce the quantity of heat passing out of the kiln to a degree where it is uneconomical to collect it for power purposes. The former method takes the form of a waste-heat installation as used in the United States, and the latter finds expression in an increase in the length of the kiln, which is the universal practice of the United Kingdom and Canada.

The proportion of cement plants in the United States which had installed waste-heat plants in 1929 was about one-third. The efficiency of modern installations has been increased to a point where they can supply the whole of power requirements of the plant. The inclusion of a waste-heat unit in a cement plant necessitates a limit in the length of the kiln. With modern waste-heat installations, the maximum length of the kiln is usually 150 ft, although in one case the kiln is 175 ft in length. Where waste-heat installations are not employed there is a definite trend toward still longer kilns and consequently lower exit temperatures, and in the United Kingdom kilns over 400 ft in length are in operation.

ROLLER BEARINGS

Roller bearings have been successfully used both in the United States and in the United Kingdom in grinding mills and in kilns. Owing to the comparative inefficiency of grinding mills, a material portion of the power supply is converted into heat instead of into the useful work of the reduction of the material. This heat, besides being wasteful, has the disadvantage of making the material, particularly clinker, harder to grind, and causing an inconvenient expansion of the mill when in operation. This expansion in the axial direction is of the order of $^3/_4$ in. in a mill 40 ft long, and special arrangements must be made for its accommodation.

In the two-point support arrangement in the lighter mill with plain bearings, where there is a central trunnion bearing at each end, it is not usual to find any arrangements for this increase and decrease in the length of the mill other than a clearance sufficient to take up its maximum axial expansion. So the condition exists where, until the heat being generated has suffused the mill as a whole to its maximum temperature, and consequent maximum length, there is an exposure of actual bearing surface to the abrasive-ground material which is present in the atmosphere to a greater or lesser extent at this point. To remove this unfavorable condition, a roller bearing has been designed so that there is no unnecessary clearance between the bearings whatever the length of the mill may be between its minimum and maximum limits.

The author describes and illustrates a roller bearing mounted remotely from the driving end of the mill on three steel parallel edges which accommodate whatever variable axial displacement exists at any time due to changes of temperature of the mill. These steel pieces take the form of an inverted V, the bottom surface being curved and having a radius equal to the normal vertical height of the V, so that in whatever position the edges may be between the prescribed limits, the height of the shaft is constant. He refers also to a three-point support arrangement for heavier mills. An alternative arrangement for large mills with central drive is to provide two roller bearings mounted end to end on the solid journal. For the largest mills this arrangement has been found to be a more economical solution than to fit one single bearing of sufficient load-carrying capacity.

In the United States an example can be taken from a Pennsylvania cement plant with combination mills fitted with Timken bearings. These mills, one on raw material and the other on clinker grinding, are $9^1/_2$ ft in diameter at the enlarged end, 8 ft in diameter in the parallel portion, and 38 ft long. Each mill, driven by a 1100-hp motor, weighs 92 tons and carries a charge of 90 tons of grinding media. The two carrying rollers at the head end of each mill are 48 in. in diameter with a 24-in. face. The roller bearings are of 16 in. bore and $26^1/_2$ in. outside diameter.

The last section of this extensive paper is devoted to details of machinery such as dust collectors, centrifugal filter and gravity separators, electrical precipitators, internal vortex separators, and flue-dust collectors. The November issue contains a brief summary of some of the features of the article. (Hal Gutteridge, in *Cement and Cement Manufacture*, vol. 3, no. 11, Nov., 1930, pp. 1453–1455, and vol. 4, nos. 1, 2, 4, 5, 7, 9, 10, and 11, Jan., Feb., April, May, July, Sept., Oct., and Nov., 1931, pp. 16–25, 169–172, 411–421, 538–545, 776–795, 1011–1024, 1129–1138, and 1223–1225, illustrated, *cdA*)

Short Abstracts of the Month

AERONAUTICS (See also Engineering Materials: Beryllium and Aeronautic Construction)

Super-High-Load Wing Sections

THE article here abstracted presents a theoretical consideration of the factors which increase the load per square foot of area of the wing, and comes to the conclusion that this increased load-carrying capacity can be obtained by promoting air circulation about the wing. Some of these methods of increasing the air circulation described in the original article act on the circulation directly, while others produce the same effect indirectly. Some of these latter methods are limited to means for restricting *décollement* or burbling without directly partaking in the creation of the movement of circulation. The methods which the author describes deal with principles and not with practical constructions. (Fr. Haus, Ch. Engr., Technical Services of Belgian Aeronautics, in *L'Aéronautique*, 13th year, no. 143, Apr., 1931, pp. 125–131, 17 figs., *t*)

ELECTRICAL ENGINEERING

Mercury-Jet Commutation

THE difference between the rotary equipment for large-power direct-current production and the jet-wave rectifier is that while in the former every care is taken to avoid sparking of the commutator, nothing is done or need be done with the latter. The jet-wave commutation is said to be found to possess certain characteristic features which would seem to render it extremely well suited for direct-current production in general, and especially adaptable to the solution of special problems in connection with the transmission of electrical energy.

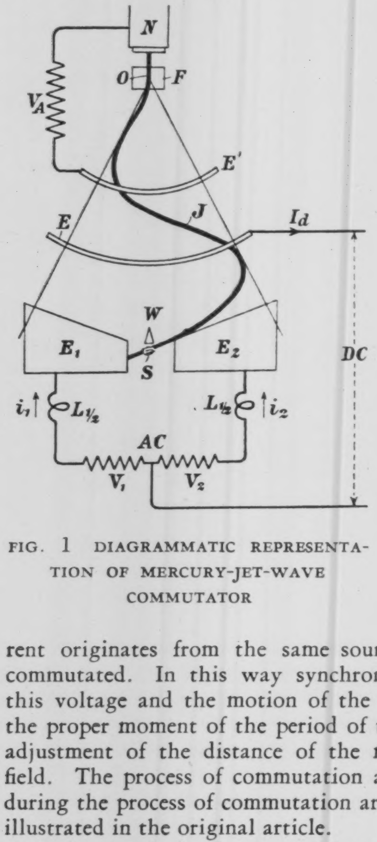

FIG. 1 DIAGRAMMATIC REPRESENTATION OF MERCURY-JET-WAVE COMMUTATOR

The principle of jet-wave commutation appears in Fig. 1. The moving member of this commutator is a wave-shaped mercury jet J, the jet wave, the particles of which are all traveling with a constant velocity V along straight lines radiating from a fixed point O. The wave as a whole moves on with this velocity, thereby alternately connecting the electrode E (the rapping electrode) with the two sides E_1 and E_2 of the main electrode. The wave is produced electromagnetically by the interaction of a constant magnetic field F and an alternating current passed through the jet. The current originates from the same source as the voltage to be commutated. In this way synchronism is insured between this voltage and the motion of the wave. Commutation of the proper moment of the period of the voltage is secured by adjustment of the distance of the main electrode from the field. The process of commutation and the current relations during the process of commutation are explained in detail and illustrated in the original article.

In this method of commutation there is sparking. The commutation is effected by a knife W made of conductive material of high melting point, generally tungsten. The knife cuts the wave, after which the spark appears, and fortunately instead of coming between the lower edges of the knife and the two sides of the cut in the jet wave, the spark chooses to settle down between the two sides of the cut, thus attacking only the material of the jet wave. This is harmless as it causes the liquid to evaporate, which does not matter as it immediately condenses again. The commutator is therefore free from wear. It is important to have means for absorbing the electrokinetic energy set free during the commutation in the time available for this absorption, and only hydrogen can do this in the case of large-power commutation. [Jul. Hartman in a paper read before Section G of the British Association, London, Sept. 30, 1931, abstracted through *Engineering*, vol. 132, no. 3436, Nov. 20, 1931, pp. 654–656 (to be continued), *dA*]

ENGINEERING MATERIALS (See also Mechanics: Effects of Bending Wire Rope)

Beryllium and Aeronautic Construction

THE present article is more or less of a general review of the extra light, light, and heavy alloys containing beryllium. In the matter of light alloys, the authors chiefly rely on American patents. Besides this they refer to the investigation by Masing and Dahl, who dealt with aluminum-magnesium-beryllium alloys containing respectively 80 and 90 per cent of aluminum. The presence of beryllium does not seem to have improved the properties of these alloys. The heavy alloys are considered by the authors as being of more immediate practical importance. They state that the addition of small quantities of beryllium to copper, nickel, and iron alloys produces considerable changes in the properties of these alloys. Thus, copper-beryllium alloys can be hardened and annealed practically like high-carbon steel, although the mechanism of hardening is quite different. The peculiar characteristics of these copper-beryllium alloys is that their modulus of elasticity in tension and in torsion is considerably affected by aging and prolonged annealing.

Beryllium steels have been recently investigated by Kroll, who studied the influence of small quantities of beryllium on iron-nickel and chrome-nickel steel, the latter with high chromium content. The effect of beryllium is particularly evident in the case of nickel steel, where it produces an increase in hardness due to aging. Beryllium additions also produce aging in stainless chrome-nickel steels of the austenitic type. The present high cost of beryllium, is, however, an obstacle to its wide introduction. (Leon Guillet and Marcel Ballay in *Revue de Métallurgie*, vol. 28, no. 10, Oct., 1931, pp. 525–528, *g*)

Metallized Terra Cotta

THE process of applying metals to ceramic products now in general use is very costly, particularly in view of the subsequent firing treatment at a temperature which is critical for the development of dunting tendencies. The author describes the process of metallizing in which the Schoop metal-spraying method is used. This was tried some fifteen years ago, but was then unsatisfactory. The new work was undertaken because of improvements in the construction of the pistol and in general technique. The pistol here used is described in some detail. Of prime importance is the nature of the surface on which the metal is to be applied, and in general the rougher the texture, the more satisfactory the adhesion. The surface must be dry and free of grease. It is important that the spray strike the work approximately at right angles, and the pistol should be held from 4 to 5 in. from the work.

The texture of the newly sprayed article resembles that of fine emery paper, and altogether fails to give the impression of being metallic at all. To develop the characteristic metallic appearance it is necessary to either scratch-brush or buff the surface. So far scratch-brushing has been found to be the more satisfactory method, and it gives a characteristic finish which is distinctive and which differs from the usual polished-metal effect. The difficulty in buffing is that so much heat is generated in the process that the metal expands and, in some cases, develops sufficient tension to partially disrupt the article. The future, however, may show some method of obviating the excessive heating up, and high polishing would then be practicable if desired. Besides the plain-metal effects, it is also possible by later chemical treatment to artificially oxidize or color the base metals, in this way obtaining pleasing color and antique effects.

Metals and alloys which have been applied on terra cotta with varying degrees of success include lead, zinc, tin, aluminum, nickel, copper, phosphor bronze, and such alloys as silveroid, goldoid, and stainless steel. Tarnishing of the metallized units in use had to be considered. It has been found that the most promising method of all is the application to the finished metallic surface of a thin coat of bakelite. However, since tarnishing occurs even in spite of that, a method has been developed of applying bakelite to both sides of the film of metal, and it is now felt that the problem has been to a large extent solved.

The Einstein electrolytic process, a secret one, has been tried but found to be much more costly and therefore abandoned. The metallization process as applied to terra cotta is in the development stage. (M. Barrett in *Transactions of the Ceramic Society*, Stoke-on-Trent, vol. 30, no. 10, Oct., 1931, original paper pp. 315–319, and discussion, pp. 319–340, *e*)

"Migra" Cast Iron

THE author describes a special cast iron intended for high-quality castings, and reports some experiments that led to the development of the new iron. Among others, several tons of a low-carbon pig iron were poured partly into sand, yielding gray cast iron, and partly in iron molds, yielding white cast iron. By subsequent annealing a part of the latter iron was malleableized, temper carbon being formed. The composition of the iron as to carbon, silicon, manganese, phosphorus, and sulphur was substantially the same. These three types of iron were remelted under identical blast conditions with the same addition of 7 lb of ferrosilicon per 220 lb of iron charge. They were poured under the same conditions into bars and various castings. The remelted products had practically the same composition throughout. The static mechanical tests showed, however, that the gray cast iron had the best properties, as indicated by Table 1.

TABLE 1 TESTS OF REMELTED IRONS

	Ultimate strength,		Transverse strength,	
Remelted from:	Kg per sq mm	Tons per sq in.	Tons per sq in.	Deflection in inches
Gray cast iron	19.4	12.3	20.5	0.33
White cast iron	14.5	9.2	16.3	0.29
Malleableized white cast iron	13.4	8.4	17.0	0.34

From this it would appear that the formation of the graphitic structure in pig iron in its bearing on the properties of the remelted product may be influenced by other variables. By a special heat treatment of the iron from the blast furnace before pouring it into pigs it has been possible to establish systematic relations between the quality of the gray cast iron produced by using this special pig iron.

This thermal treatment is based on the principles of superheating the iron, although it will require the observance of certain given limits for temperature and time of treatment which differ considerably from the data published so far in literature. As the new special pig iron is characterized by a remarkably fine graphite grain and fracture, it has been given the trade name "Migra" iron (Micro-Graphite).

The original article reports tests with this iron, including mechanical tests. The refined qualities imparted to the Migra iron are also reproduced in the remelted product, but only when the intermediate heat treatment has been performed in a special manner. It is claimed that the new iron can be used where it is desired to produce an iron of good casting qualities, high machinability, great density, and high mechanical properties. It is also claimed that it may replace charcoal iron in the production of chilled castings, rolls, and ingot molds. (E. Piwowarsky and A. Wirtz in *Giesserei*, vol. 18, no. 36, Sept. 4, 1931. Compare *Foundry Trade Journal*, vol. 45, no. 792, Oct. 22, 1931, pp. 251–252 and 254, 2 figs., *pd*)

FOUNDRY

Effect of Excessive Atmosphere Moisture in Cupola Blast

ABOUT seven or eight years ago, automotive engineers began to decrease the cylinder diameter of automobile motors and to use narrower piston rings. Consequently piston-ring foundries were called upon to produce much lighter castings than they had been accustomed to make. With the production of these lighter castings, the problem of hard iron became a serious one.

In the foundry of The Piston Ring Company it was discovered that the light castings would be hard at times, and at other times, with apparently no change in the practice, they would be soft and machinable. This condition continued for two or three years, and gradually there developed in the minds of the operators of the foundry the conviction that weather conditions, with respect to the moisture content of the atmosphere, constituted an important influencing factor so far as hard iron was concerned.

Certain changes were made in molding methods and other details, and when these were completed the effect of atmospheric moisture again began to be noticed. During the summer of 1928, at the suggestion of the late Dr. Richard Moldenke, a refrigerating system was installed to control the moisture of the blast. The author describes what their experience was on a day when the moisture content of the air was high. The troubles that occurred were ascribed to retardation of the normal dissociation of the cementite into ferrite and graphite. The author's theory was that oxygen over a certain amount causes cast iron to chill when poured into light-section castings, and that this excess of oxygen may be due to high moisture in the air. When the excessive moisture in the cupola blast was eliminated the hard-iron losses dropped to an almost negligible percentage. Fully 75 per cent of the cupola operating difficulties have disappeared. Because of smoother and more accurate control, the company has been able to make reductions in the amounts of limestone and fluorspar used, and in the amount of coke between charges. These have more than offset the operating costs of the system, and as a result the better quality of iron produced has been all clear gain.

Among other things, the author states that the fluidity of iron is closely connected with the oxygen content of the metal. It has been the author's experience that iron with an oxygen content high enough to cause chilled piston-ring castings is very fluid. On the other hand, he believes, as a result of his own experience, that if the oxygen content of cast iron is reduced below a certain point, the iron will become very sluggish and will not run even comparatively simple castings.

Certain tests of fluidity are described. A short description of the moisture-control system is also appended. A temperature of 35 F is maintained as the air leaves the brine spray. Since the air is saturated, this means that it contains just a trifle over 2 grains of water per cubic foot. (Neil A. Moore, Metallurgist, The Piston Ring Co., Muskegon, Mich., in

Transactions and Bulletin of the American Foundrymen's Association, vol. 2, no. 9, Sept., 1931, original paper, pp. 285–288, 1 fig., and discussion, pp. 288–296, *dt*)

FUELS AND FIRING

Tangential Firing of Gaseous and Liquid Fuels

TANGENTIAL or corner firing has been used principally in firing pulverized coal. Installations have been made which demonstrate that this method of firing is also suitable for gaseous and liquid fuel.

In firing with gas as a fuel it was first necessary to develop proper burners, and when this was done it became apparent that best results were obtained when the furnaces were not pushed too hard, which meant that it was necessary to increase the furnace volume so as to take full advantage of the burners. But while a large furnace volume is essential to good combustion, the shape and disposition of the furnaces should be such as to make it entirely effective. The first step in this direction was to increase the turbulence of the gas and air streams as they leave the burner, but even under this condition the mixture was found slow to ignite but had a tendency to long flaming. The reason for this is that the gas contains a large percentage of inerts, and in order to speed up ignition it is necessary to bring the gas and air together very rapidly. This means a furnace construction which will also prevent or minimize the possibility of sintering of any dust accumulations that may occur.

The steam-generating units embodying these principles at the Sparrows Point Plant of the Bethlehem Steel Co. have demonstrated that the combustion can be speeded up and the flame shortened to the extent that no traces of carbon monoxide are present in the gases after they have passed through the lower furnace water screen. The heat absorption of the water-wall surface is uniform, and is constantly maintained at a high point by the revolving column of gases, the sweeping action of which serves to prevent the formation of comparatively stagnant and cold gas layers along the walls. In addition to this, the efficiency of the wall as a heat-absorbing medium is maintained at a high point, because any dust or slag accumulations, after a time, fall off and drop into the ashpit. Sintering is eliminated because a relatively low furnace temperature is maintained by the high heat-absorption efficiency of the walls. While tangential firing is responsible for the manner in which this unit performs, the use of highly preheated air must not be overlooked. The temperature of the air leaving the heater with gas firing, reaches 400 F. It is therefore not necessary for the furnace to supply all the heat required for the ignition of the fuel. Under these conditions, the resulting furnace temperatures are higher than if cold combustion air is used. Where washed gas saturated with moisture is used, hot air is particularly advantageous as it accelerates ignition.

The original article also describes the units installed at the Cambria plant and at the Lackawanna plant of the Bethlehem Steel Co. In all of these cases the operation is said to have been quite successful. This is followed by a description of the generating unit recently developed by the Combustion Engineering Company. In this unit (Fig. 2) the furnace is completely surrounded by water-cooled surface capable of high rates of heat absorption. The fuel is fired tangentially from the four lower corners of the furnace. Water-screen protection is provided so as to prevent the slagging of the accumulated ash in the pit. The superheater is screened from the direct radiant heat of the furnace by four rows of tubes and is located above the furnace. It is stated that in fully water-cooled furnaces with tangential firing, washed blast-furnace gas, notwithstanding its high moisture content, difficult ignition, slow burning, long flaming, and varying dust content, has been burned successfully at rates varying from 6000 to 36,000 Btu per cu ft per hr. With this fuel, the resulting efficiencies are as high, if not higher, than those previously possible to obtain. Pulverized coal, fuel oil, and by-product tar have also been burned, with relative ease, at varying rates. The only change necessary for the handling of any of these fuels consisted in changing the types of fuel nozzles in the furnace corners. If it is so desired, it is possible to permanently install burners to handle coal, oil, and gas, and these fuels may be burned simultaneously or separately as desired. Changing from one fuel to another may be accomplished on very short notice. (Otto deLorenzi, Combustion Engineering Corp., New York, in *Combustion*, vol. 3, no. 4, Oct., 1931, pp. 11–15 and 21, 4 figs., *d*)

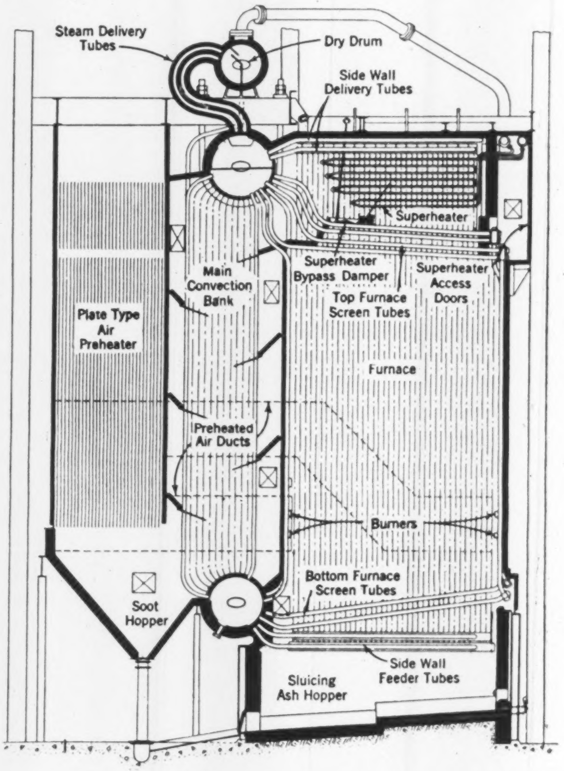

FIG. 2 COMBUSTION ENGINEERING COMPANY'S STEAM GENERATORS FOR TANGENTIAL FIRING

HYDRAULIC ENGINEERING (See Pipes: Failure of Water Mains)

INTERNAL-COMBUSTION ENGINEERING

Closed System of Cooling for Diesel Engines

THE article here abstracted is the first of two on the subject of the closed system of cooling for Diesel engines. The closed system of cooling is necessary where either the available supply of water is insufficient or the water is of such characteristics that it cannot be conveniently used in the engine.

In the closed system the jacket water is not exposed to the air for direct cooling, but is cooled indirectly by passing it through heat exchangers or coolers. As usually designed, the closed system does not have any great amount of storage of jacket water. Some make-up water is required on account of losses occurring around the engines and water absorbed by small leaks in the system. The cooling water is usually raw water from the locally available supply. The choice of the type of cooler to be used depends on the hardness of the water, space limitations, initial cost, and maintenance. The first consideration is of fundamental importance from an operating standpoint. The shell-type cooler is to be preferred in situations where the rate of accumulation of scale from the raw water is not too rapid.

With respect to hardness of the water, the type of cooler to be used might be specified as follows: Total hardness of the raw water up to five grains per gallon, no coolers required; total hardness from 5 to 35 grains per gallon, use atmospheric-type coolers. If the total hardness exceeds 60 grains per gallon, there is likely to be great trouble in maintaining the cooling surfaces sufficiently free of scale, and it will be found particularly desirable to keep considerable quantities of water overflowing continuously from the cooling pond or tower basin in order to keep down concentration of solids in solution.

The advantages o the shell-type cooler with respect to accessibility and cleaning are obvious. The fact that shell-type coolers are made truly counterflow in principle while this effect is not fully realized in atmospheric-type coolers, and that the former have the advantage of good water velocities both inside and outside the tubes, is partially offset by the evaporative-type coolers. In cost of installation the atmospheric-type cooler is the more expensive of the two on account of increased height required in the cooling tower, the special distributing system needed in the tower, and the cost of suitable cleaning racks, which should be provided.

The most important advantage to be obtained in the use of atmospheric-type coolers is their scale-shedding feature. Secondary to this feature is the ability to observe at any and all times the condition of the exterior cooling surfaces with respect to scale and other deposits.

In atmospheric-type coolers a certain amount of cooling is obtained by virtue of evaporation which occurs on the tube surfaces. This advantage, however, must be evaluated merely by its effect on the cost of installation for a certain prescribed duty as compared with an alternative proposal. The remainder of the article in the October issue and the first part of the November issue are devoted to suggestions as to the installation of shell-type and atmospheric-type coolers. In the November issue suggestions are also given as to pump installation.

Inasmuch as the jacket water reaches the pump suction at nearly the temperature of discharge from the engines and this temperature will ordinarily be 110 to 115 deg and may during hot weather and at times of heavy load and heavy atmospheres reach 125 to 130 deg, it is recommended that the pumps be set at an elevation below the level of the water in the sump. This eliminates the necessity of providing special priming arrangements and permits the pumps to pick up the water instantly when they are started up. This feature is of great importance in the plant-operating routine.

It is pointed out that although it is good practice in design to limit the discharge temperature of the jacket water to 115 deg, no great hazard will exist even though it should rise temporarily 25 to 30 deg above that figure if the flow is steady and uninterrupted; but that an interruption in the flow, even of very short duration, occasioned by the fact that there is a suction lift on the pump and the pump has lost its suction due to air leakage or high temperature of the water, is very likely to cause cracking of cylinder heads.

Some of the author's suggestions as to cooling towers and spray ponds and emergency supply tank are new. (T. A. Burdick, Alco Products Co., New York, in *Diesel Power*, vol. 9, nos. 10 and 11, Oct. and Nov., 1931, pp. 495–498 and 554–556, 7 figs., *dp*)

MACHINE PARTS AND DESIGN

The Inverse Geneva Wheel Motion

THIS motion is the invention of J. R. Schultz, of the E. W. Bliss Co., Brooklyn, N. Y. It was developed about fifteen years ago to fill the requirements of a practical type of drive for feeding strip stock into power-press dies, and has been applied to a variety of successful applications in automatic machinery. Little or nothing, however, has been published regarding its action and peculiarities.

The term "inverse" is applied to this form of Geneva mechanism for producing intermittent circular motion because the driving and driven members rotate in the same direction, whereas with the usual form of Geneva motion the rotations are reversed. The arrangement is such that the driving-crank axis and the crank circle are entirely within the radius of the plate or driven member, and this produces a very different effect in the timing, acceleration, and the velocity of the plate.

Some typical forms of the inverse Geneva wheel are illustrated in a figure which shows a three-station plate. The essential parts are few and simple, consisting of a constant-velocity driving crank and a variable-velocity driven member called the plate. The plate rotates in equal intermittent movements from station to station, stopping for a short interval of time at each station. As the rotation of the plate is caused by the motion of the crankpin roller in passing through radial grooves in the plate surface, the number of stations is dependent upon the number of grooves.

The smallest number of radial grooves with which a Geneva mechanism will function is three. The greatest number is infinite, being limited only by the diameter of the plate and the width of the grooves, both of which may theoretically be made to any proportions. In actual practice, however, the number of grooves required is not very great.

The article gives some details as to the selection of the angles of the driving crank and the idling angle, as well as some practical points to be considered in the design of an inverse Geneva stop. The locking arrangement is described and illustrated in the original article. (Warren P. Willett, Asst. Designing Engr., National Automatic Tool Co., Richmond, Ind., in *Machinery* (New York), vol. 38, no. 4, Dec., 1931, pp. 260–261, 3 figs., *d*)

MARINE ENGINEERING

Design of American Super-Liners

THE purpose of this paper is to describe the design and general characteristics of the liners which the United States Lines propose to build for the North Atlantic service. It was found expedient to develop two designs, one embodying geared-turbine and the other turbo-electric propelling machinery. These are going to be really huge liners, with a length overall for the geared-turbine-drive ship of 963 ft 3 in., propelling machinery with a normal shaft horsepower of 146,000 at 160 rpm, and a maximum shaft horsepower of 180,000 at 174 rpm. There will be eighteen water-tube sectional express boilers with a total boiler heating surface of 286,920 sq ft (steam pressure, 400 lb gage; steam temperature, 700 F, both at superheater outlet).

The ships are to operate through the fall, winter, and spring months on a normal schedule at a speed of about 28 knots, and during the summer months at about 30 knots.

In order that they may be driven at high speed in heavy headwater the ships are to have a raked stem and a high freeboard forward. The hull has a cruiser stern and bulbous bow. Aft the hull is cut away in contour and is fitted with a spade-type, streamlined balanced rudder. The arrangement for the machinery and boiler compartments are such as to secure the greatest safety so the vessel can reach port from mid-ocean in case of damage.

The propelling units for the geared-turbine-drive ship are of the four-pinion, single-reduction gear type arranged on four shafts with the inboard propellers turning outboard and the outboard propellers turning inboard. In the electric-drive ship there is a four-shaft arrangement with a single motor on each shaft. The inboard propellers turn outboard and the outboard propellers turn inboard.

The boiler installation is considered an outstanding feature of these vessels. In each case the maximum rated power is developed with two boilers idle. This gives an opportunity for cleaning the boilers at sea and enables these units to be maintained in the most efficient condition. The output per boiler is over 11,000 shaft hp. As each boiler has a heating surface of 15,940 sq ft, this represents only about 0.7 shaft hp per sq ft of heating surface, which is a moderate amount. With a steam demand for all purposes of 1,650,000 lb per hr when the propelling machinery is developing 180,000 shaft hp, the evaporation per sq ft of heating surface is only about 5.75 lb per hr. Conditions are here made more nearly like the modern power plant ashore, where fewer and larger steam-generating units are the accepted practice.

It is believed that there is now no merchant vessel afloat that has boilers of a greater unit output than those proposed. Yet the units are of such number that ample flexibility of power is possible.

The propelling machinery consists of four sets of quadruple-expansion turbines, the high-pressure and the first intermediate-pressure turbines running at 2000 rpm, the second intermediate-pressure and the low-pressure at 1100 rpm, and the propeller at 160 rpm. For both drives the power is divided equally on four shafts, each shaft in the gear drive being driven by quadruple series steam turbines through four pinions engaging with a main single-reduction gear. In the turbo-electric drive each shaft is driven by a three-phase synchronous-type motor direct-connected to the main thrust shaft, and current is supplied by four three-phase turbo-alternators. The condensers are of the underslung type and have scoop circulation.

Control of the propeller revolutions for both ahead and astern movement of the vessel will be by means of the turbine throttles only, and there are to be no pole-changing devices. There is one main condenser for each turbo-alternator, designed and proportioned to maintain at normal power an absolute pressure not in excess of $1^1/_2$ in. mercury with circulating water having a temperature not below 70 F.

Vapor from the evaporator shells is utilized for purposes requiring low-pressure saturated steam, including steam to the second-stage feedwater-heater shells, and to the vessel's heating system. Under certain conditions of operation it may also be introduced into the propulsion turbines.

Feedwater heating is done in two stages with a terminal temperature of 300 F at the boiler checks. The heating agent for the first-stage heaters will be made up of auxiliary exhaust, steam bled from the propulsion turbines, and drains from the second-stage heaters. The heating agent for the second-stage heaters will be steam bled from the propulsion turbines together with drains from the evaporator coils.

In order to keep the weights down and the machinery spaces as small as possible, but consistent with good design, sectional express-type water-tube boilers without air heaters or economizers have been adopted. Without air heaters or economizers this type of boiler has an efficiency of $81^1/_2$ per cent. With air heaters the overall efficiency would be increased approximately $3^1/_2$ per cent.

The introduction of air heaters was given much consideration. It was found that the height of the boiler casings would have to be increased to such an extent that about 3000 to 4000 sq ft of deck space now occupied by crew's quarters would be lost. The number of oil burners per boiler would have to be increased by about 40 per cent. The air pressure in the boiler compartments would have to be increased from about $2^1/_2$ in. to about 5 in. water gage.

The power to drive the forced-draft blowers would be about double that required without air preheaters. There would be a substantial increase in the weight of the boiler plant. This would amount to 200 tons for the geared installation, and to 225 tons for the electric installation. Owing to the increase in the number of burners, there would be an increase in the number of firemen required. The boiler casing would be more complicated, due to the additional ducts required to convey the heated air down to the furnaces. There would be an increase in the first cost of the installation, with resulting increase in the carrying charges. The maintenance cost would be increased.

Development work was carried on with the Babcock & Wilcox Company with regard to fitting air heaters and economizers to the sectional express boilers, together with a study of stowage space, changes in arrangement of decks, etc., with a view of securing about 88 per cent boiler efficiency, together with other refinements in the machinery installation, with the expectation of reducing the fuel consumption to approximately, or only a little above, 0.60 lb of oil per shaft hp.

Because of the increased initial cost, extra weight, and the increased cost of upkeep and maintenance involved as compared with a lighter, simpler design, the air heaters and economizers were not adopted. This decision was further influenced by the fact that vessels operating on a two-week schedule in the summer months have very little layover time at New York and Southampton for cleaning boilers, which are the most troublesome part of the machinery equipment; therefore the simpler the boiler installation, the easier it is to maintain the sailing schedule. Estimates which were made show a greater return on the capital investment by adopting the simpler and lighter boiler plant than by adopting a heavier and more complex one with its higher thermal efficiency.

Two plates in the original article show the steam distribution in the heat balance. As they cannot be reproduced, because of lack of space, it may be mentioned in connection with the geared-turbine drive that, beginning at the boiler plant, the total evaporation for 180,000 shaft hp is 1,652,258 lb per hr with a heat content of 2,250,375,396 Btu. The boiler efficiency used ($81^1/_2$ per cent) is conservative, actual tests of considerable duration at the testing plant of the League Island Navy Yard, Philadelphia, having indicated to the satisfaction of observers that a mean of $81^1/_2$ per cent can be maintained in service continuously.

The remainder of the article is primarily of importance to naval architects and cannot be abstracted here. However, particular attention is called to the part dealing with efforts to minimize vibration and racking. (Theo. E. Ferris, Naval Architect and Marine Engineer, New York, N. Y., in a paper before the general meeting of *The Society of Naval Architects and Marine Engineers*, Nov. 19 and 20, 1931, 32 pp., illustrated, and 13 plates, *d*)

MECHANICS

Effects of Bending Wire Rope

THERE is a suspicion that the popular formulas for the estimation of the loss of strength due to bending wire rope may not be correct. The purpose of the present paper is to analyze this problem in the light of available material. Wire rope is one of the most used, and most abused, commodities of industry. Therefore all its properties should be known, to the end that the public and the wire-rope manufacturer may agree upon the increase in its cost, if necessary to provide for more safeguards in the selection of materials and in the process of manufacture, so that its performance may be predicted for a properly supervised service.

The author starts with a general discussion of the manufacture of wire rope and a classification of its types. From this he proceeds to an analysis of the strength of the rope strand as compared with the sum of the strengths of the individual wires. He considers the case of a curved wire about a straight center wire and that of a curved wire about a curved center wire, and gives formulas for both cases. He points out that foreign rope lists carry higher breaking strengths than those of American manufacturers.

Some reference is made to the effect of varying diameter of the helix. As regards bending stresses in wire ropes, the usual procedure is to rely upon the theory of flexure as developed for homogeneous prisms. It is admitted that the theory of flexure is only approximate, and its use is permitted in engineering calculations because a great number of physical tests have demonstrated its limitations. The author enumerates the assumptions on which it is based, and derives a formula for the unit bending stress in a rope.

A large part of the literature on wire rope is devoted to the presentation of tables and diagrams of stresses due to bending, which are based directly, or with slight modification, upon these formulas. In the opinion of many this information is most deceptive, and has played a prominent part in blocking the advance of the engineering profession to a true knowledge of the behavior of a wire rope in service.

To investigate the matter, certain tests were carried out. A discrepancy found between theory and practice is ascribed to the fact that the wire rope in passing around the sheave has but one point of distortion, namely, the point of tangency of the rope and the sheave. The author next summarizes some of the formulas for bending stress, and proceeds to show that wire rope is a systematic grouping of wires into helixes bent about a core that may be regarded as having the properties of a yielding foundation. He derives several formulas for P, which is the axial load sustained by a wire of the strand. The value of P multiplied by the number of wires in the rope gives the loss of strength due to bending. He also derives a formula for the total service stress.

An equation is likewise derived for an elastic curve of a locked-coil cable supporting a carrier. The following passage from the author's conclusion is quoted verbatim.

"In any symposium for the improvement of the service life of wire the issue must be joined by considering this question: Can the processes involved in the manufacture, the rolling of rods, the drawing of wire, the laying of wire rope, and its uses be brought under critical technical control to the end that a behavior of the wire rope in service may be predicted with assurance? Of course, some ropes fail to render service. The wonder is that so many prove satisfactory in spite of abuse and neglect. It is probable that the improvement of wire rope will be the result of a gradual advance in the control of the basic operations of its manufacture and use." (Frederick Carstarphen, Consulting Engineer, Denver, Colo., in *Proceedings of the American Society of Civil Engineers*, vol. 57, no. 10, Dec., 1931, pp. 1439–1466, *mtA*)

Strength of Sector of a Circular Plate Between Two Radial Ribs

FOR the uniformly loaded sector of a circular plate an exact solution of the proper equation can only be obtained by expanding the uniform rate of loading per unit surface into an infinite series when the sector may be considered as resting free on the two radii at its edges. The equation is given in the original article. When, however, the circular plate has radial ribs, the only admissible supposition is that the sector is rigidly fixed to the ribs. For this case a method of approximation is proposed by the author, such as has already been adopted by H. Lorenz for rectangular plates (*Zeitschrift des Vereines deutscher Ingenieure*, 1913, p. 623). According to this method the bending is taken proportional to a suitable function which satisfies the conditions of stressing and deformation existing at the edges of the sector. The coefficient of proportionality follows from the consideration that the work of internal deformation must be equal to the work done by the external forces. An expression for the bending is found in the original article in the shape of a rather complicated formula. The maximum bending according to the formula takes place at $r = {}^2/_3R$. The expression for the maximum bending involves the maximum contour factor, and values for this are given for various numbers (from 12 to 4) of radial ribs. The stresses are given in the original article, and it is stated that the maximum radial stress is situated at the outer edge in the middle of the arc, while the maximum tangential stress is situated at the ribs halfway between the apex and the arc of the sector and "also, but only slightly less, in the center line of the sector" at certain distances from the apex. In the case where the number of ribs is eight, the maximum tangential stress is equal to the radial stress. When there are more than eight ribs the tangential stress in the middle of the rib is greater than the radial stress; when there are fewer than eight ribs, it is less and in the middle of the arc. A formula is given for the maximum bending in a rigidly fixed sector with six ribs, which, however, is approximate only. (G. Ei. in *Sulzer Technical Review*, no. 4, 1931, pp. 16–18, 3 figs., *mt*)

Bursting Strengths of Cold-Drawn Brass Tubes

THE term "internal couple" in the case of cold-drawn brass tubes implies the couple produced by the resultant of the tensile stresses on the outside layers and the compressive stresses on the inside layers. The original article gives the results of tests intended to detect the variation in the possible kinds of stress distributions in cold-drawn tubes, and describes how they were carried out. The curves presented are representative of the kinds of variation that have been discovered, and are claimed to show that the stresses are so distributed as to give them diminishing thickness, (*a*) increasing dis placements, (*b*) decreasing displacements, and (*c*) constant displacements. In some samples there were no displacements at all, which denotes the absence of harmful stress. From these experiments the author concludes that the displacements depend upon the rate of removal of stress. He then tells how to find the initial longitudinal couple, for which he gives an expression. He next proceeds to describe a method for finding the initial circumferential couple, for which he also gives an expression.

After this, tests were made to measure the bursting strength of initially stressed and unstressed samples parted off the same tubes as used in previous experiments. One sample was heated for two hours at 250 C to eliminate its internal stress, as it was known that this low-temperature annealing releases the internal stresses without affecting hardness, strength, or microstructure.

From these tests it was found that there is no serious difference between the bursting loads for stressed and unstressed samples. Therefore it may be concluded that the initial internal stresses have no serious effect on the strength of cold-drawn tubes. Both the initial, internal, longitudinal, and circumferential couples increase with increasing "sink." (Jas. Fox in *Mechanical World and Engineering Record*, vol. 90, no. 2340, Nov. 6, 1931, pp. 454–457, 13 figs., *e*)

METALLURGY (See Engineering Materials: "Migra" Cast Iron)

PIPES

Failure of Water Mains

AT A MEETING of the Council of the Institution of Water Engineers, London, England, on March 1, 1929, a subcommittee was appointed to inquire into the question of the failure of water mains. A report of the committee has now been published.

From a general examination of the figures presented, it is apparent that the liability of water mains to fail decreases as their size increases, and that 3-in. mains are by far the most vulnerable, other factors besides mere size being here operative.

As regards the effect of frost, it has been found that installations drawing their supplies from wells or other underground sources have a much smaller number of failures than those depending upon surface supplies. The size of main has a clear influence upon the number of failures, and the smaller the pipe, the more liable it is to fail.

It is only in the case of the smaller mains, particularly those having rigid joints where expansion and contraction are not possible, that the fractures can be fairly definitely ascribed to the difference in temperature between the water admitted to the mains and the temperature of the soil. In other instances it is difficult to determine whether the damage would have taken place if the pipes had not been detrimentally affected by some other cause, such as electrolysis, graphitic deterioration, etc.

In more recent years it has been the custom to pay greater attention to the depth at which water mains are laid. In 1895, the year of the great frost, it was recorded in London that the temperature was below 32 F on twenty-five days from January 25 to February 18, but the temperature of the earth at a depth of 1 ft below the surface fell below 32 F on twelve consecutive days only. A table sets forth an interesting comparison of the temperatures of the water in the trunk mains and the earth at a depth of 4 ft below the surface during 1929.

The effect of traffic and vibration is next discussed. Special mention is made of the effect of the use of pneumatic tools in breaking up the foundations of the roads, which has been found to cause gas leakage from lead joints.

The greater liability to failure in the case of small-sized mains in cold weather may be attributed to some extent to the number of supply pipes, hydrants with their connections, and other apparatus in which the water lies nearer to the surface of the ground.

The proximity of tramways is in many cases a contributory cause of failures. (*Journal of the American Water Works Association*, vol. 23, no. 12, Dec., 1931, pp. 2067–2084, *g*)

REFRIGERATION

The Pak-Ice Machine

THIS machine was designed primarily for the storing up of refrigeration in the form of frozen liquids, such as water or brine. The product is not in the form of transparent blocks, and can best be sold as crushed ice. As the product comes from the machine it is in the form of small crystals suspended in water. The water can be pressed out or otherwise removed. The machine consists of a cylinder with a corrugated liner fitted into an outer casing. Liquid ammonia is fed into the space between the two. The inside of the liner is filled with circulating water which freezes rapidly on the liner surface and is constantly removed by tool-steel scrapers. The rapidity of freezing is such that the entire capacity of the cylinder, about 15 gal, is frozen in less than 4 min. The corrugations in the liner increase the area of freezing surface 400 per cent; the ice film is not allowed to grow thicker than 0.008 in.; the water circulates over the freezing surface at the rate of 18 ft per sec. The metal wall which transfers the heat is $^{5}/_{16}$ in. thick, and the jacket is flooded completely with liquid ammonia which is boiling at a furious rate. All of these factors, particularly the high speed of the circulating liquids, account for the high rate of production.

As compared with the standard can system, the present method of ice making produces a saving in building and floor space. The freezer, ammonia accumulator, water pump, ammonia compressor, and motor for the above-mentioned production may all be mounted on a base 4 ft × 12 ft.

The ice produced is stored automatically in a bin refrigerated just enough to prevent the ice from melting. The machine may be used for freezing various concentrations of brine to be used for the production of temperatures below 32 F. Solutions of sodium chloride containing 23 per cent of salt have been frozen with a suction pressure of about 6 in. vacuum. The machine discharges the product in a semi-solid condition at a rate of about 20 lb per min, and the output may be increased by precooling the solution going into the freezer. These frozen brines appear to have good possibilities for the icing of refrigerator cars for meat and frozen products. Experiments in car icing are described in the original article. (Wm. H. Taylor in *Refrigerating Engineering*, vol. 22, no. 5, Nov., 1931, pp. 307–309, 3 figs., *d*)

TESTING APPARATUS

Stroboscopic Methods of Investigating the Action of Machinery

THE author deals with methods based on the use of the stroborama, a device which has been described in American publications. (See MECHANICAL ENGINEERING, vol. 45, no. 11, Nov., 1923, p. 663, and vol. 47, no. 11, Nov., 1925, p. 926.) He applies it to the study of propellers, injectors, and motors, and incidentally describes briefly and illustrates an installation for photographing air propellers by means of exposures lasting one-millionth part of a second. This latter was made possible by the use of a recently invented auxiliary to the ordinary strobotama consisting of a luminous tube and a special condenser, so arranged that a single flash of the stroborama, even when lasting only about one-millionth of a second, is sufficiently powerful to produce a picture on an ordinary photographic plate. The position in which the machine is photographed may be determined by means of a synchronizer controlled by the machine itself in series with another synchronizer operated by hand. The spark may, however, be produced by the machine itself, as would be done in photographic non-periodic movements; for example, a bullet can make a contact in passing between two metallic wires, and the rupture of a piece of metal can be photographed at the instance when it occurs by the parts themselves establishing the contact. (L. and A. Seguin, Directors of the Mechanical and Physical Research Co., in *L'Aeronautique*, vol. 143, Apr., 1931, pp. 132–135, 10 figs., *d*)

Gas Measurement in the Metric System

THIS method of measurement is assuming increasing importance among companies operating in Mexico and along the Mexican border. Under this system gas is measured in cubic meters, pressure in kilograms per square centimeter, and temperature in degrees centigrade. Orifices are measured in millimeters, and recording differential gages register millimeters of water pressure. In conversions and calculations a method making use of the cubic foot absolute will greatly lessen the labor and increase accuracy in the calculation.

Just as the cubic foot absolute is secured by multiplying either standard or flowing cubic feet by the pressure in pounds per square inch absolute and the reciprocal of the absolute temperature in degrees fahrenheit, the cubic meter absolute may be derived by multiplying either standard or flowing cubic meters by the pressure in kilograms per square centimeter absolute and the reciprocal of the absolute temperature in degrees centigrade. The conversion from cubic feet absolute to cubic meters absolute may be made by means of the multiplier 0.003584, made up of

$$\frac{9}{5} \times \frac{1}{14.2232} \times \frac{1}{35.314}$$

For the conversion from cubic meters absolute to cubic feet absolute, the reciprocal, 279.02, is used.

Having reduced the volume of metric units to the cubic meter absolute and then to the cubic foot absolute by means of the above multiplier, in order to get the equivalent volume in English units at any pressure or temperature, it is only necessary to multiply by the absolute temperature and the reciprocal of the absolute pressure.

As the base pressure in countries using the metric system is often one kilogram per square centimeter, the base-pressure multiplier would be: (Atmospheric pressure + gage pressure)/1, both pressures being expressed in kilograms per square centimeter. Thus, to secure this multiplier it is only necessary to add the gage pressure to the atmospheric. It is of course necessary to have temperature multipliers for degrees centigrade, and extensive tables in centimeters or millimeters and kilogram units. (W. P. Porcher, Measurement Engineer, Texas Cities Gas Company, El Paso Division, in *Western Gas*, vol. 7, no. 12, Dec., 1931, p. 40, *p*)

TEXTILE MACHINERY

Textile Mills Converted to Electric Drive

ELECTRICITY replaced steam in a large Yorkshire worsted and a Scottish tweed factory. The former is located at West Riding and is the Whetley Mill of Daniel Illingworth & Sons, Ltd. While the mill is located in the heart of a large city like Bradford, it nevertheless has a generating plant of its own installed. Steam is used for process work, but amounts only to about 18 per cent of that required for generation. It is stated, however, that the decision was arrived at after a careful study of the overhead costs for both private generation and pipe supply. The new generating plant consists of a geared turbo-alternator (2500 kva, 440 volts, three-phase, 50 cycles) for providing the day load and a reciprocating steam engine coupled to a 300-kw alternator for the night-load supply. On both the turbine and the engine arrangements are made for steam bleeding for process work. The savings already effected indicate the wisdom of the capital investment, to say nothing of the increased production of the mill. The steam required for all purposes with the old plant was 45,000 lb per hr, while the consumption under new conditions is 32,000 lb per hr. The demand for process steam has been reduced from 8000–9000 lb to 5000–6000 lb per hr. The consumption includes a new lighting load of 70 kw.

A further saving of about 7 per cent in steam consumption is expected when the steam pressure is increased from the present 120 lb per sq in. to the 220 lb per sq in. for which the boilers have been designed.

The total load on the motors is 2450 hp, while the aggregate capacity of motors installed is 2690 hp, a close margin tending to high commercial efficiency. All the motors are of simple, robust squirrel-cage construction, and up to 30 hp they are switched directly on to the line, thus enabling an inexpensive form of switchgear to be employed.

The installation in the mill was difficult because the layout of the textile machinery provides little or no floor space for the motors. Therefore in each of the seven spinning rooms four 60-hp, 720-rpm motors are housed in steel structures attached to the roof girders, a pair of motors in each structure. Each motor drives eleven spinning frames. In the roving department 10-hp motors are housed in the cradles suspended from the roof girders. Each motor is directly coupled to a high-speed shaft with a jockey pulley, and the drive is taken down to the frame. The methods of installation in the drawing, carding, and combing rooms are described in some detail.

Another mill-drive conversion is that at the Buccleuch tweed mill at Langholm, Scotland, owned by Arthur Bell & Co. In this case there was no pipe supply available and the mill shafting was originally driven by a 150-bhp gas engine supplied from a producer plant on the site. Here the new power is provided by a B. & W. water-tube boiler with a chain-grate stoker and superheater and a Green economizer. The boiler steam conditions are 200 lb per sq in. and 537 F; the generating equipment consists of a turbine, gear coupled (8500 to 1500 rpm) to a 150-kw alternator of 400–440 volts and 50 cycles.

The turbine has four stages and 5000 lb of steam per hr can be bled from it at 20 lb per sq in., the pressure being controlled automatically by the pass-out valve gear, irrespective of quantity. Arrangements have been made for the utilization automatically of live steam in the event that the demand for process steam exceeds the quantity passed out from the turbine.

As soon as the pressure in the low-pressure steam receiver is reduced to 18 lb per sq in., an "Arca" valve in the saturated-steam line automatically admits steam from the line at reduced pressure. The receiver is situated in the low-pressure main and acts as a buffer in the event that the process-steam valves are opened very rapidly.

Details as to the installation are given in the original article. It is said that the conversion has effected a saving in fuel- and ash-handling costs, greatly reduced smoke emission, and gives a steadier driving, great reduction of noise, and easy starting with auxiliary power. (*The Electrical Review*, London, vol. 109, no. 2818, Nov. 27, 1931, pp. 805–806, *d*)

THERMODYNAMICS

Relation Between Heat Transfer and Surface Friction for Laminar Flow

THE heat transfer from a surface immersed in a moving fluid depends not only on the surface friction, but also on the general fluid flow in the neighborhood of the surface. Any attempt to obtain a theoretical relation between heat transfer and surface friction, therefore, necessarily involves the establishment of a connection between surface friction and the neighboring fluid flow, and consequently the problem must be restricted to those types of motion for which such a connection can be found. There appear to be only two types of motion for which this requirement can be fulfilled: first, flow in pipes, and second, flow past surfaces for which the boundary-layer theory is applicable.

The paper gives a mathematical theory of the heat transfer from a surface over which the fluid flow in the boundary layer is laminar and two-dimensional when the heat flow is steady. It also gives a general differential equation for heat transfer at any point in the boundary layer, which, after simplification, has been solved by artifices similar to those used to obtain a solution of the boundary-layer equations.

The solutions obtained were adapted to two problems of practical interest, (*a*) the heat transfer from a plane placed in a fluid stream in the direction of motion, and (*b*) that from a generator strip of a circular cylinder. In each case relationships were obtained between the intensity of heat transfer and surface friction. These theoretical relationships were compared with those obtained from measurements of the heat transfer from a thin platinum foil placed in a wind stream and from a nickel strip embedded just below the surface of a cylinder. The intensity of surface friction for the platinum foil was known theoretically, and that for the cylinder was taken from earlier experiments.

The agreement between theory and experiment was close for both the plate and cylinder. (A. Fage and V. M. Falkner in ***Reports and Memoranda No. 1408*** (Ae. 529) British Air Ministry, 30 pp., 12 illustr., Apr., 1931, *tm*. Abstracted from press release)

WELDING

Welded Boiler Drums

THE address here abstracted describes various methods of welding, with particular reference to those employed in boiler manufacture.

The author shows that flash welding is not properly suited to the manufacture of large boiler drums, because of the enormous cost of equipment. Spot welding is difficult to apply to heavy plates, and is rarely used with plates thinner than $^3/_8$ or $^1/_2$ in. Projection welding is likewise rejected. Resistance welding is used for tube-welding manufacture, particularly for thin-walled tubing.

The author discusses next the various forms of arc welding and the various methods of protecting the metal from oxidation and absorption of oxygen. This latter is done by the use of coated or covered electrodes, or by protecting the metal in its passage across the arc by a stream of combustible gas around the arc, usually hydrogen or of the hydrocarbon variety. The oxyacetylene flame when properly adjusted produces its own protective elements in the form of the products of combustion. As regards the strength of weld, the following is stated:

The physical properties of a piece of steel depend largely upon its chemical composition and upon its heat history. All metal is crystalline in its structure. When steel cools from the molten state it crystallizes, and these crystals combine in groups to form what are commonly known as grains of varying shapes and sizes, and the size of these grains is largely a question of their heat history, that is the temperature to which the metal has been raised, the time it has been held there, the rate of cooling, etc. Under the conditions of cooling in the ordinary arc weld the grains are very coarse, and, although the metal may have ample tensile strength, it is almost universally brittle. By proper heat treatment such metal may be refined as to its grain size, with an accompanying change of properties, particularly as to its ductility.

It just happens that in the making of arc welds in heavy plates it is practically necessary to deposit the metal in layers, in which case each layer puts the layer below it through an ideal heat treatment as far as grain refining is concerned. This is particularly true in heavy-plate welding where large currents are used and where sufficient heat is thereby transmitted to the underlying layer to carry it through this refining process. It is obvious, however, that the depth of penetration of the refining heat is limited, and therefore that it is necessary to restrict the thickness of the layers to that point.

The author brings up the following important question: When is the slightly lower ductility of one of these welds without grain refinement any serious handicap to the safety of the resulting structure, assuming of course, that the tensile strength of the joint is equally high in both cases (and this is a fact)? He does not answer the question completely, but states as his personal opinion that there are very few structures in which this lower ductility has any influence on their satisfactory service. In the case of arc welding with either bare or covered electrodes, great care is necessary to avoid gas or slag pockets or the finer type of porosity, with the consequent danger of fatigue failure starting at this point. The following passage is quoted verbatim: "You have doubtless been told that welds are being made which are superior in every respect to the parent metal, and this is in general true, but I wish to assure you that this is not the whole story, and that it is not a simple matter to produce a perfectly homogeneous nonporous weld metal. If the pores are very small and uniformly distributed, they will probably not affect the satisfactory functioning of the resulting joint in any way, but the larger pockets are distinctly dangerous, and these do occur occasionally in the best-regulated families."

The author refers in this connection to Professor Moore's report on breathing tests of cylindrical shapes, and reference to the A.S.M.E. Boiler Code Committee requirements of X-ray tests should prove the absence of slag or gas pockets in the welded joints. (Dr. Comfort A. Adams, School of Engineering, Harvard University, Cambridge, Mass., in ***Combustion***, vol. 3, no. 4, Oct., 1931, pp. 16–21 and 24, *gA*)

SYNOPSES OF A.S.M.E. PAPERS

THE papers abstracted on this and following pages appear in the current issues of the Materials Handling, and Oil and Gas Power sections of A.S.M.E. Transactions. These sections have been sent to all who registered in the similarly named Divisions. Other sections are in the course of preparation and will be announced, when completed, in later issues of "Mechanical Engineering." Copies of these papers may be obtained by those not registered in these two divisions by addressing the Secretary of the A.S.M.E., 29 West 39th Street, New York, N. Y.

MATERIALS HANDLING

Mold-Handling Methods in Foundries

THIS paper analyzes the mold-handling problem in foundries, first listing the important features to be considered in a study of the application of mold-handling devices. Present-day practice in intermittent and semi-continuous foundries is reviewed. The numerous advantages and reasons for lower cost production in continuous mold-handling operations as compared with floor methods are given. The design and application of continuous power-operated mold conveyors are discussed, with illustrations of several types. (Paper No. MH-53-5, by William L. Hartley.)

Synchronization of Production Control With Conveyorization

MASS-PRODUCTION methods are applied to a plant making a variety of things by concentrating for a definite period on one thing, making a supply for distribution over a certain length of time, and then turning the plant's efforts to producing another type of product. This paper deals with the production control of a partly conveyorized plant of the Westinghouse Company where 1500 operators produce certain domestic and commercial heating devices. (Paper No. MH-53-6, by E. M. Olin and W. C. Beattie.)

Material Handling in Mass Production at the General Electric Plant

IN THIS paper the author describes the conveyor system used throughout the various buildings where refrigerators are made by the General Electric Company. Before this installation material was handled by tractor-and-trailer trains, lift trucks, and gas and electric trucks. The new system has eliminated congestion, retracing of material routes, delays in schedule, spoilage of material, and maintenance and replacement of the industrial trucks. The conveyor serves as a traveling stockroom, thus releasing floor space for use in manufacturing operations. The conveyor system has linked together four different sections located in 12 separate buildings and maintains a uniform flow of material. (Paper No. MH-53-7, by H. C. Rundle.)

Handling Bulk Materials Mechanically

THE paper outlines the general characteristics and fields of applicability of the numerous types of mechanical handling and conveying equipment. It also covers the types commonly used for handling such bulk materials as coal, coke, sand and gravel, crushed stone, lime, cement, phosphate and fertilizer, grain, cottonseed, sugar, earth, foundry sand, etc. No attempt has been made to cover overhead cranes and hoists, crawler and locomotive cranes, and such dock handling equipment as bridge tramways, unloading towers, lift-type car dumpers, etc., all of which are also used for handling bulk materials mechanically. (Paper No. MH-53-8, by William W. Sayers.)

The Industrial-Type Internal-Combustion-Engine Locomotive

THIS paper seeks to show that the internal-combustion type of locomotive can be used to advantage and at a much lower operating cost than the steam locomotive for industrial-plant use. The electric drive, in combination with gasoline or Diesel engines, places the internal-combustion type on a par with the steam locomotive as far as mobility is concerned, and ahead of the latter type with respect to availability for service, economy of operation, safety, visibility, convenience, and general performance. The electric drive is declared to be better than the conventional clutch and gear transmission between engine and axle as being better to operate, having more tractive power on grades, and in being much easier on the engine. There is available a wide range of internal-combustion-type locomotives using electric drives. (Paper No. MH-53-9, by S. B. Schenck.)

Types of Materials Used in Materials-Handling Equipment

MATERIALS-HANDLING equipment means to most people a conveyor for carrying solids, but the author defines it also as a pump for handling liquids or a steel cylinder for transporting gases. The material used in the construction of such equipment must meet a wide variety of conditions. The author discusses wood, concrete, glass, rubber, copper, lead, nickel, aluminum, and iron and steel. The fundamental research initiated within the last ten years by the large steel companies furnishes a foundation which few other industries possess for the production of many new alloys. (Paper No. MH-53-10, by Hervey J. Skinner.)

Suspended Cables With Large Sags

THE curve assumed by a cable having its own weight and the applied load uniformly distributed over its length differs but little from a parabola if the deflection or sag is small; but as the actual curve is a catenary, modified more or less by the elastic deformation of the cable, the difference between the two curves becomes too great to be disregarded when, in the case of suspended structures other than suspension bridges, the sag exceeds a certain limit. The catenary being an exponential curve, its solution presents unavoidable difficulties. As a means of overcoming these in great measure, the author has compiled a table of hyperbolic radians tabulated as angular functions, whose use he shows by means of several worked-out examples. (Paper No. MH-53-11, by Robert C. Strachan.)

OIL AND GAS POWER

Heat Recovery From Internal-Combustion Engines

CITING the heat losses of locomotives and steam turbines, the authors aver the internal-combustion engine to be the most efficient mechanism for converting heat into useful work; yet even in this, two-thirds of the heat is wasted in exhaust gases and in cylinder jackets. The need for further heat conservation is urgent. In considering the recovery of heat from exhaust gases of internal-combustion engines, the authors lay down seven basic conditions. Adding to these limitations the avoidance of back pressure and the provision of a simple way of decarbonizing the heating surface, the designing of the ideal waste-heat boiler is not a simple matter. The evolution of the "thimble tube" boiler after 30 years of experience is described, and tables and charts are given which show typical examples of heat-recovery tests with internal-combustion engines of both four-cycle and two-cycle types. The largest internal-combustion engines are to be found in marine installations, and the authors point out that it is therefore not surprising that hitherto there has been more heat recovery practiced in such installations than in the case of land services. (Paper No. OGP-53-4, by Thos. Clarkson and Wm. Bradford.)

Dispersion of Sprays in Solid-Injection Oil Engines

IN INVESTIGATING the problem of how to improve atomization and dispersion in the solid-injection oil engine, the knowledge of the mechanism of spray formation was found to be scant. In the researches covered by this paper, it was not attempted to develop a spray theory. A few experiments were made for the purpose of clearing up which physical forces do or do not participate in the atomization and distribution process. A large number of charts have been made representing sprays under various conditions, these seeming to point to the following general conclusions: Dispersion becomes more even when injection pressure is increased, when the oil viscosity is decreased, and when the air density is increased; the cone angle increases with increasing oil pressure, increasing air density, and decreasing viscosity of oil; a larger percentage of oil reaches a given distance in a spray having a slenderer spray cone; no definite influence of orifice dimensions was noticeable in using cylindrical orifices of the dimensions employed in the tests discussed.

The experimental method described and the procedure of evolution employed are easy to apply, and the results give a ready means of judging the spray from the point of view of its applicability in an engine. It is recommended as a useful tool in development work in oil-injection engines, and, the author believes, its general adoption is likely to lead to a better understanding of the influence of spray pattern on the performance of the engine. (Paper No. OGP-53-5, by Kalman J. De Juhasz.)

Experiments on the Flow of Air Through Engine Valves

THE resistance of air flow through poppet valves has been tested experimentally by the authors. The experiments which they carried out and describe include flow in both inlet and exhaust directions, and the ranges of valve opening and of pressure head extend to or beyond the limits which normally may be utilized in practice. Individual valves were tested variously mounted, and pairs of valves were tested as grouped in an actual design.

The experiments have been extended in an effort to improve the flow characteristics of the poppet valve by modification of its shape and that of the valve approaches. (Paper No. OGP-53-6, by E. S. Dennison, T. C. Kuchler, and D. W. Smith.)

Development of the Double-Acting Engine

IN LESS than a decade there has been development of the Diesel double-acting engine into a reliable prime mover. Double-acting engines for large-power-plant work are attracting attention. A committee studying types of equipment for the extension of the Copenhagen electric-power station has recommended acceptance of a Burmeister & Wain double-acting, two-cycle engine of 18,500 bhp, with continuous overload capacity of 22,500 bhp. At present the two-cycle type of engine has forged ahead of the four-cycle design. The steps in the development of the double-acting engine are reviewed in some detail by the author. (Paper No. OGP-53-7, by Louis R Ford.)

Light-Metal-Alloy Pistons and Rods in High-Speed Industrial Engines

THE speed of oil and gasoline internal-combustion engines has been brought into a higher range following the availability of improved materials and the necessity of obtaining increased power output without sacrificing space and weight. This often makes it necessary to reconsider some points of design and to adopt better grades of material to solve the problems of higher heat stresses and increase in dynamic bearing loads. Therefore the piston is sometimes cast of steel in thinner section and the cylinder liner is made thinner and is cast of steel to reduce thermal stresses. Connecting rods are made of special alloy steels and can safely withstand much higher stresses than are allowed in plain carbon steel. As a satisfactory means of reducing the weight of pistons and rods, the author discusses the use of aluminum, allowing heavier sections, preserving the rigidity, and removing any thermal difficulties encountered in the piston. (Paper No. OGP-53-8, by Benedict J. Isidin.)

The Diesel-Engine Situation Today

THE first commercially successful Diesel engines were a product of American manufacturers, but now large Diesels are being built principally in Germany. This country, however, is making considerable headway in the manufacture of engines up to 1000 bhp per cylinder. The author discusses developments in atomization, combustion, and supercharging. He feels that there is now a need for standardization, but it must not interfere with progress. (Paper No. OGP-53-9, by Max Rotter.)

The Quiescent Combustion Chamber

THE term "quiescent" is originated as describing more accurately than "non-turbulent" the condition of the combustion chamber in some fuel-injection engines at the time of injection of the fuel. Such a combustion chamber is considered quiescent if the movement of the air has no appreciable effect on the distribution of the fuel to the air with which it must unite during the process of combustion. Performance tests of a single-cylinder unit furnished the material for the paper, in the general program of the National Advisory Committee for Aeronautics in investigating the compression-ignition, fuel-injection engine as a source of power for aircraft. The simplest combustion chamber is the quiescent one, and the simplest injection orifice is the round hole; and the main tests were directed toward obtaining the optimum combination of these two elements. The discussion neglects entirely the effect of various factors on the physical parts of the engine, because in its more than 800 hours of operation there were no failures or replacements of parts due to conditions of operation. (Paper No. OGP-53-10, by John A. Spanogle.)

Correspondence

CONTRIBUTIONS to the Correspondence Department of "Mechanical Engineering" are solicited. Contributions particularly welcomed at all times are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on its activities or policies in Research and Standardization.

Faraday and Edison

TO THE EDITOR:

On page 942 of the December, 1931, issue of MECHANICAL ENGINEERING, under the heading "Faraday and Edison," appears the following statement:

> Crude and obviously untenable as this seems to us now, it was accepted without question by every one at that time, and it remained for the practical genius of Edison to realize that current generated by a dynamo should be consumed as far as possible in the outside circuit, where it could do useful work, and not be transformed into heat in the interior of the generating machine. From this came the early Edison generators with efficiencies of more than 80 per cent, that is, far beyond what was then considered the maximum possible theoretical efficiency of the machine, and it was only because of the availability of these efficient generators that the growth of practical applications of the electric current became possible.

It is not to be wondered at that such a statement might now be made by those writing of the electrical art in the times referred to, as there are very few of the pioneers left capable of giving a proper interpretation of the situation at that time. Permit me, however, to call attention to the fact that in lighting the Avenue de l'Opera and the Place de l'Opera in Paris in 1878 by Jablochkoff candles, the energy for which was generated by Gramme machines, the proper relation of external resistance to internal resistance of the Gramme dynamo was known to the designers of the Gramme machines at the time, as pointed out by E. Hospitalier in an article written by him in *La Lumière Electrique* of Paris, dated September 15, 1879. The resistance of the external circuit, as compared with the resistance of the armature in these dynamos, was considerably in excess and indicated that the principles were well understood.

Also, in 1878 there was a report of the Committee of the Franklin Institute on Dynamo-Electric Machines printed in the *Journal* of the Franklin Institute for May and June, 1878, and on page 31 of this report the following statement appears: "This loss is nearly compensated by the advantage this machine possesses over the others of working with a high external, compared with the internal, resistance, this also insuring comparative absence of heating in the machine." This has reference to comparison of a Brush machine with one of the Gramme machines.

There was another paper, entitled "Circumstances Influencing the Efficiency of Dynamo-Electric Machines," read before the American Philosophical Society, November 1, 1878. From this paper I quote the following: "In respect to the relations that should exist between the external and internal work of dynamo-electric machines, it will be found that the greatest efficiency will, of course, exist where external work is much greater than the internal work, and this will be proportionately greater as the external resistance is greater.

The article referred to in *La Lumière Electrique*, as above stated, was written by E. Hospitalier, and the subsequent work referred to on dynamo-electric machines at Philadelphia in 1878 and 1879 was participated in by my colleague, Prof. E. J. Houston, and myself

ELIHU THOMSON.

Lynn, Mass.

[The basis for the statement which Dr. Thomson quotes at the beginning of his communication came from the book, "Edison—His Life and Inventions," by F. L. Dyer and T. C. Martin, published in 1910 by Harper Bros. On page 292 of Vol. I, where the subject of the efficiency of electrical generators at the time Edison was beginning his work is discussed, it is stated that a Commission of the Franklin Institute found that a conversion of 38 to 41 per cent of the motive power into electricity was the most economical at that time. Dr. Thomson's interesting letter shows, however, that other investigators of the time also recognized the fact that the efficiency of a dynamo would be greater when its internal resistance was lower than that of the external circuit.—EDITOR.]

A 732-Mile Pipe Line

TO THE EDITOR:

In the November, 1931, issue of MECHANICAL ENGINEERING, on page 836, there appeared an abstract of a paper of mine on the subject "A 732-Mile Pipe Line," in which it was stated that no details of the process used—the shielded arc—were given. I have therefore thought that perhaps it would be well at this time to give a brief statement of the principle of the shielded arc.

The shielded-arc process utilizes a heavy coating on the outside of an electrode of mild steel of proper specifications. This coating, burning in the arc less rapidly than the electrode melts, forms in effect a crucible around the arc, protecting it for almost its entire length. As the coating burns it gives off the oxidizing gas which prevents oxygen and nitrogen in the ambient atmosphere from reacting with the molten metal. The shielded-arc process, eliminating oxides and nitrides in this manner, gives improved ductility, tensile strength, and resistance to corrosion. By its employment porosity is avoided, and the layer of easily removable slag, the residue of the burning coating, forms a protection for the hot metal while cooling.

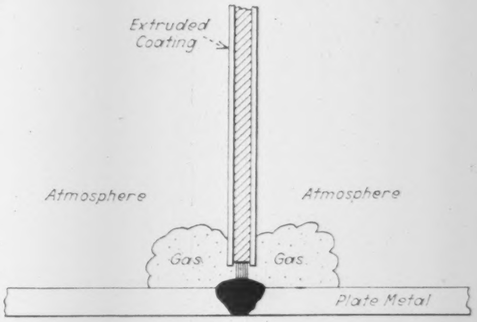

FIG. 1

A. F. DAVIS.[1]

Cleveland, Ohio.

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[1] Vice-President, The Lincoln Electric Company.

Education for Industry in Times of Depression

TO THE EDITOR:

To urge the advisability of training more workers at the present time when the country is struggling with the problem of unemployment may impress some persons as being the height of poor judgment. A little thought, however, will show that this is not so. Ordinarily, many youths enter employment as workers or as apprentices each year in the various factories of the country and in the building trades. For two years this group has not been recruited by industry because of the depression. They are either unemployed, or are working on farms, or are making shift at some temporary employment until they can be absorbed into the industry in which they are really interested. In the meantime the supply of workers in the factories and in the building trades is being reduced each month by old-age retirements and by deaths.

The result is that there are actually fewer mechanics and trained men in the country today than there were a year ago, and still fewer than there were two years ago. This is true, notwithstanding the present surplus of workers. When business recovers and those who now are idle are drawn into employment again, it will then be found that a sufficient supply of skilled workers is wanting in many lines. The individuals will be available, but they will not have been trained unless they are encouraged to get such training during this period of general underemployment.

There are two chief factors in this situation: First, many of the existing apprentices in industry are working short time or have been laid off, and their training retarded or discontinued; second, the boys and girls who under normal conditions would be recruited as apprentices have not been so recruited. With regard to the apprentices already at work part time, or at work occasionally, their training should be continued and their interest maintained by means at least of the classwork which as apprentices they have been taking. Unfortunately, during periods of depression many companies discontinue these classes, under the impression that they are not needed because the number of apprentices is small. It is very important that the classwork normally supplementary to regular shopwork be continued during times of depression, in order that the apprentices may not lose their interest, and in order that they may make as rapid progress as the conditions will permit.

It is not so easy to attract the second group, that is, the boys and girls who have not become apprentices because of the prevailing depression and who are either idle, working on farms or at other makeshift employment, awaiting a time when they can enter the employment in which they hope to find their careers. One would think that in periods of depression the boy who has not yet entered upon gainful employment would feel a greater necessity for profiting by such school facilities as exist in his neighborhood than in normal times. This, however, is not the case. At such times there appears to be a falling off of the students in attendance at evening classes of an industrial nature, even in public schools, where the training is offered free of charge. Apparently the existence in the community of numbers of workers who are skilled in their lines but cannot secure employment, deters boys and girls who are ambitious to enter such lines from taking the necessary training. If they could be reached, they might be made to see the wisdom of preparing themselves and maintaining their morale under these rather trying circumstances. The heads of training programs in plants, in their interviews with young men and boys looking for work, could well stress this point. It would undoubtedly make an impression, with valuable results in proportion.

In spite of the now prevailing unemployment, industrial executives should be concerning themselves with the future supply of skilled workers; they should see to it that every effort is made to maintain the training of those apprentices that are still employed, and that boys and young men now inquiring in regard to employment are advised to obtain the kind of training that will prepare them now for such employment hereafter. Educational departments, which are frequently reduced in slack times because of the general necessity for cutting the overhead to a minimum, should not be unduly impaired. Plans that have been adopted for the training of apprentices should not be abandoned, but should be carried through as fully as possible, in the certainty that eventually these workers will be needed.

This is written at the suggestion of Prof. R. L. Sackett, chairman of the A.S.M.E. Committee on Education and Training for the Industries.

JOHN T. FAIG.[2]

Rotating Air Cylinders and Adapters

THE proposed American Standard for Rotating Air Cylinders and Adapters has six tables of dimensions for air cylinders of sizes 3 to 10 in., inclusive, pull and stress data at 100 lb per sq in. air pressure, dimensions for air-cylinder adapters, sizes *a*, *b*, *c*, and *d*, with a table of sizes of adapter screws and tapped holes. One page of the proposed standard is reproduced here. Complete copies may be obtained from C. B. LePage, Asst. Secy., A.S.M.E., 29 West 39th Street, New York, N. Y.

Air Cylinders

Sizes 3-Inch to 8-Inch Inclusive

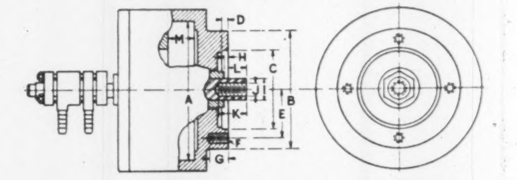

Table 1 Dimensions

Size of Cylinder	Bore of Cylinder				Radius of Adapter Screw Circle	Tapped Holes for Adapter Screws[2, 7] F		Length of Thread[3]	Minimum	Maximum Piston Rod Dia.	Tapped Hole in Piston Rod[4, 7] J		Length of Thread[5]	Minimum[6]	Piston Stroke
	A	B	C[1, 8]	D	E	Dia.	Pitch	G	H	I	Dia.	Pitch	K	L	M
3	3	4⅝	3 000	5/16	1⅞	⅜	16	¾	1/16	1	¾	16	1½	1	1
4½	4½	4⅝	3 000	5/16	1⅞	⅜	16	¾	1/16	1	¾	16	1½	1	1
6	6	6¾	4 500	5/16	2¾	½	13	1	1/16	1¼	¾	16	1½	1	1½
8	8	6¾	4 500	5/16	2¾	½	13	1	1/16	1¼	¾	16	1½	1	1½

All dimensions in inches.

[1] NOTE—A tolerance of +.002 is permitted on this diameter.

[2] NOTE—4 tapped holes 90 deg. apart, National Standard Coarse Thread, Class 3 Fit

[3] NOTE—Thread to be tapped full depth for length "G".

[4] NOTE—Tapped hole in piston rod, National Standard Fine Thread, Class 3 Fit

[5] NOTE—Thread to be tapped full depth for length "K".

[6] NOTE—The end of piston rod is 1 inch from face of cylinder hub at one end of stroke and 1 inch plus the length of stroke from this same face at other end of stroke.

[7] NOTE—Counterbore 1/64 inch larger than nominal diameter and 1/16 inch deep.

[8] NOTE—Chamfer corner on diameter "C", 1/32 inch.

Table 2 Pull and Stress Data at 100 lb. per sq. in. Air Pressure

Size of Cylinder	Size of Adapter[1]	Pull in Pounds (100 lb. per sq. in. Air Pressure)	Area of Draw Rod at Root of Thread (sq. in.)	Stress in Draw Rod (lb. per sq. in.)	Total Root Area of 4 Adapter Screws (sq. in.)	Stress in Adapter Screws (lb. per sq. in.)
3	A	707	356	1,990	279	2,530
4½	A	1,590	356	4,470	279	5,700
6	B	2,827	356	7,940	516	5,480
8	B	5,026	356	14,120	516	9,740

[1] NOTE—See Table 5, page 6.

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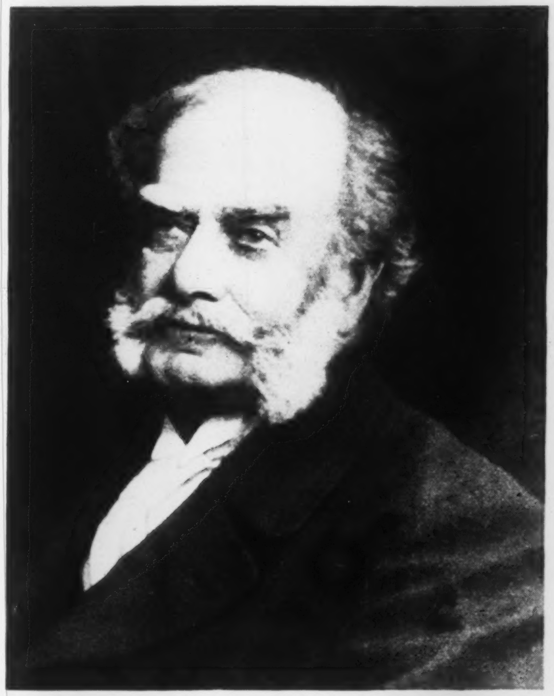
[2] President, Ohio Mechanics Institute, Cincinnati, Ohio. Mem. A.S.M.E. Committee on Education and Training for the Industries.

SIR ALFRED YARROW, 1842–1932

SIR ALFRED YARROW, shipbuilder, naval engineer, philanthropist, and honorary member, A.S.M.E., who died at the age of ninety on January 24, 1932, was well known for the boiler that bears his name and for the high-speed and shallow-draft vessels made at his works on the River Clyde. He was born into the age of steam that had developed out of the introduction of the engine, the locomotive, and the steamship. Endowed, as his schoolmaster said, with "a talent for engineering and a thirst for affection—to give and to take," and, as he himself once said, with a good constitution and a necessity of working, he made more profitable use of his talents and his opportunities than do most men. He inherited from his mother an ability for affairs unusual in an engineer, good health, and longevity (she lived to be 95), and from both his parents a warmth of human sympathy and understanding which directed the abundant philanthropies made possible by his well-earned prosperity. Starting his apprenticeship to an engineering firm at the age of fifteen, he was more fortunate than most men in being able to crowd into an active three-quarters of a century an extraordinary list of good works. His approach to engineering was a strictly practical one; his school was the shop and drafting room; and no small measure of his success lay in the intrepid pioneering spirit that gave him courage to try new and apparently impossible tasks, such as constructing a steamship that could be taken apart and carried in 50-lb pieces through 60 miles of African jungle, and vision to seek through research the necessary data upon which to base new developments. His specialties, shallow-draft steam yachts, mostly used on rivers in undeveloped countries, and high-speed vessels for the British and other navies, demanded pioneering and research methods, for almost every ship was constructed for an unusual purpose, or to travel at a hitherto unattained speed. It was characteristic of him that he should have been the first to set up and operate a privately owned telegraph in London; that, when less than twenty, he should have constructed a steam-propelled road vehicle which, on its nocturnal travels between Greenwich and Bromley at twenty-five miles an hour, had the misfortune to cause a horse to shy, a mounted policeman to break his leg, and an aroused parliament to pass a bill prohibiting the use of steam upon the road, unless the carriage were preceded by a man carrying a flag; and it was equally characteristic of this same spirit of progress that he should donate £20,000 to the Royal Society in 1911 for an experimental tank for shipbuilders at the National Physical Laboratory at Teddington; and later, in 1923, to offer the same society £100,000 to be used at the discretion of its council in promoting scientific research.



A. F. Yarrow

Alfred Fernandez Yarrow was born in London on January 13, 1842, the son of Edgar and Esther (Lindo) Yarrow. His mother was the daughter of Moses Lindo, a Jewish merchant who had been in business on the island of St. Thomas, West Indies, and for whom Edgar Yarrow worked as a clerk. After some schooling, in which he showed an aptitude for mathematics and science, Alfred Yarrow, at the age of 15, was apprenticed for a period of 5 years to Messrs. Ravenhill, marine engineers, builders of marine engines. During his apprenticeship his spare time was spent in shops, in attendance at engineering meetings and lectures (Faraday was demonstrating new-found scientific principles before large audiences during these years), and in working at home. Inventive ability, which had manifested itself in childhood and sometimes led to mischievous pranks, found expression before the lad was twenty in two devices that were developed in cooperation with his chum, James Hilditch: an improved method for steam plowing, and a steam-propelled road carriage, both of which were taken over by others on a royalty basis; and also gave rise to the building of the steam yacht *Isis*, the first of the long line of vessels that the famous shipbuilder was to produce.

It was the success that attended the building of the *Isis* that finally encouraged Yarrow to undertake the building of small yachts. Ravenhill had held out small inducement for the ambitious boy, and finding a partner and a site for a shop at Poplar, on the Isle of Dogs in the River Thames, the first works with a sign bearing the name Yarrow & Hedley, Engineers, was started. In 1868, after advertising his ability to build steam launches, Yarrow received his first order, a 24-ft steam launch for Colonel Halpin, and thereby established a profitable business. Differences between Yarrow and Hedley terminated the partnership in 1875. Up to that time 350 steam launches had been built. Having bought out Hedley, Yarrow continued the shipbuilding business with rapidly growing success to the day of his death, moving his works to Scotstoun, on the Clyde, in 1906.

An impressive list of steam launches have come out of the Yarrow Works. An unusual problem in shipbuilding was successfully solved in the construction of the 55-ft *Ilala*, launched in 1875 on Lake Nyassa, Africa. It had been designed so that no piece weighed more than 50 lb, and was bolted rather than riveted together. After a trip up the Zambesi and Shiré rivers, it was taken apart and carried 60 miles through the jungle and reassembled without loss or injury of a single part.

Between 1877 and 1879 Yarrow, who was specializing in the newly conceived torpedo boat, arranged first for spar torpedoes and subsequently for self-propelled Whiteheads, built torpedo launches for the Argentine, Dutch, French, Russian, Spanish, Austrian, Italian, and Chilean governments. The British Admiralty Torpedo Boat No. 425, built to a guarantee of 18 knots, actually realized 21.9 knots, and led Yarrow into some interesting and valuable experiments on 25 propellers. His first ocean-going torpedo boat, the *Batoom*, built in 1880, made 22 knots. By 1892 these smaller craft had developed into the destroyer class, of which the *Havock* and *Hornet*, 180 ft long and developing 4000 hp, were conspicuous examples. The *Havock* had the usual locomotive type of boiler and made 26.1 knots, but in the *Hornet* had been placed the new Yarrow water-tube boiler. With 11 tons less weight, the *Hornet* made 27.3 knots. Speed was raised again by the Russian yacht *Sokol*, holding a record of 30 knots, and, in 1899, by the Japanese destroyer *Sazanami*, 220 ft long, 6000 hp, which made 31 to 32 knots.

In 1910 Yarrow convinced Lord Jellicoe and subsequently Lord Churchill that, in view of developments elsewhere, the 27-knot destroyer class should be replaced by ships of greater speed and the *Firedrake*, *Lurcher*, and *Oak* were built, the *Lurcher* attaining a speed of 35.345 knots.

The Yarrow boiler, familiar to all engineers, was developed between 1877 and 1887.

With the coming of the World War, Yarrow's speedy destroyers gave valiant aid to the British Navy. Twenty-nine of these ships were built from August 4, 1914, to November 11, 1918, and with the success of the Tigris flotilla, brought Yarrow the baronetcy shortly after. Of these vessels the *Tyrian* made 40 knots.

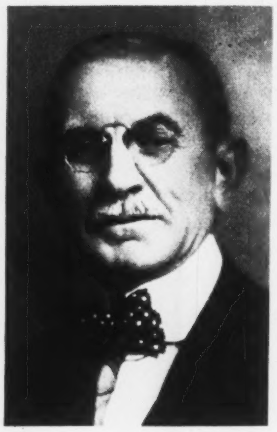
No less famous than the torpedo boats and destroyers were numerous shallow-draft steamers built by Yarrow. In addition to the *Ilala*, a ship of a special sectional construction was built in which Stanley explored the Congo in 1883. The sections could be carried on a steamer and lowered over the ship's side and assembled afloat, and could be carried overland on specially provided carriages. For navigating the upper Nile four boats were built in 1874. Of these no part weighed more than a camel could carry. They were driven by means of a stern wheel. In a fruitless attempt to save Gordon at Khartoum, two shallow-draft gunboats, the *Lotus* and the *Waterlily* were built in 1884. In 1897 a Nile expedition under Lord Kitchener used the *Sheik*, a 24-in.-draft gunboat with its screws in a tunnel and provided with the Yarrow hinged flap that subsequently became a feature of the ships of the Tigris Flotilla. For use on the Yangtze Kiang, in 1903, the gunboat *Widgeon*, 160 ft long and of 27 in. draft, was designed.

Sir Alfred was married in 1875 to Minnie Franklin, who died in 1922. Six children were the result of this union: Harold Edgar, now managing director of the Yarrow & Company, Glasgow, who succeeds to the baronetcy; Norman Alfred, managing director, Yarrows, Ltd., Victoria, B. C.; and Eric, killed at Ypres; and three daughters. Sir Alfred's second wife, who survives him, is Eleanor Barnes, author of "Alfred Yarrow, His Life and Work."

Sir Alfred was elected an honorary member of the A.S.M.E. in 1914. He had been a member of the Institution of Civil Engineers since 1869 and a member of its council, of the Institution of Mechanical Engineers since 1889, and of the Naval Architects and Marine Engineers, which latter society he served as vice-president in 1896.

Max E. R. Toltz

1857–1932



MAX E. R. TOLTZ

MAX E. R. TOLTZ, whose death occurred at his home in St. Paul, Minn., on January 11, 1932, was born at Koeslin, Germany, on September 2, 1857, the son of Hermann and Malvine (Beilfuss) Toltz. He attended the Royal Gymnasium at Koeslin and the Royal Polytechnikum in Berlin, receiving a civil engineering degree in 1878. Ramsey Institute of Technology, St. Paul, conferred the degree of Doctor of Engineering upon him in 1924.

Major Toltz served a short apprenticeship with a Berlin firm dealing in pumps and water-works equipment, and was connected with the Prussian Government as assistant engineer until he came to the United States in 1882. He became a citizen in 1889.

During the first twenty-five years in the United States Major Toltz was active in the development of railroads, especially in the Northwest. He was connected with the St. Paul, Minneapolis & Manitoba, later the Great Northern Railway, from 1882 to 1904, being promoted through various positions from draftsman to mechanical engineer in charge of motive power. During the next three years he was consulting mechanical engineer at the Angus shops in Montreal and at the Winnipeg shops of the Canadian Pacific Railway, and at the Jersey City shops of the Erie Railroad. He also held the position of vice-president and general manager of the Manistee & Grand Rapids Railroad.

Major Toltz had devoted himself entirely to consulting work since 1907. During the first three years of that time he was engaged in special work on electrification for the Great Northern, Northern Pacific, Butte, Anaconda & Pacific, and Chicago, Milwaukee & St. Paul railroads, and on ore docks for the Great Northern, Northern Pacific, and Soo lines. In 1910 he organized the Toltz Engineering Company, St. Paul, and was president of it and of its successor, Toltz, King & Day, Inc., formed in 1918, until his retirement from active business in 1928. He specialized in labor-saving machinery, hydroelectric and steam power, grain elevators, and docks, and held patents on steam superheaters, car lighting, and iron-ore docks. He had contributed a number of papers to the technical societies of which he was a member and to the technical press. These dealt with highly superheated steam and its applications, the distillation of peat coke, compressed acetylene gas, and other subjects in his field.

During the World War Major Toltz, who had been a captain in the Minnesota National Guard for many years, received his commission as a major in the Construction Division of the Quartermaster Corps. He supervised the construction of General Hospital No. 2 at Ft. McHenry, Baltimore, Md.

Major Toltz gave much of his time and ability to the advancement of the engineering profession. He was a valued member of the St. Paul Chapter of the American Interprofessional Institute, also a director of its national board. He was a past vice-president of the American Society of Civil Engineers and a member of the American Institute of Electrical Engineers.

the American Railway Master Mechanics Association, and the American Society of Military Engineers. He had served as president of both the Engineering Society of St. Paul and the Federation of Architectural and Engineering Societies of Minnesota. He was a member of the Verein deutscher Ingenieure.

Major Toltz became a member of the A.S.M.E. in 1904. He was a manager of the Society from 1914 to 1917, and a vice-president during the next two years. He was one of the organizers and the first chairman of the Local Section at St. Paul, and was a member of its executive committee at the time of his death. He was also serving on the 1932 Nominating Committee of the Society and on the Committee on Awards. In 1925 he established a fund of $15,000, the income of which was to be used for loans to students of engineering, under the administration of the A.S.M.E. In his will he has provided similar funds to be administered by the American Society of Civil Engineers and the American Institute of Electrical Engineers.

Among other organizations to which Major Toltz belonged were the St. Paul Engineers' Club, the Minnesota and University Clubs, and the Masonic fraternity. He was an honorary member of Pi Tau Sigma, honorary mechanical engineering fraternity. He was a Christian Scientist, and made bequests to several of its churches and other organizations.

Major Toltz is survived by his widow, Mrs. Elizabeth (Argue) Toltz, whom he married in 1919, and by three grandchildren through a former marriage.

Viscount Ei-Ichi Shibusawa

1840–1932

JAPAN'S "grand old man," Viscount Ei-ichi Shibusawa, died November 11, 1931. He was 91 years old. One of America's earliest and most steadfast friends in Japan, he was called the "people's foreign minister" because of the trips he made to the United States, particularly when Japan's immigration question was under discussion. For years he was the nation's leading banker, merchant, industrialist, and mine owner, and one of the founders of Japan's modern business system. His power at home was exceeded only by that of the royal family.

Viscount Shibusawa's friendship for the United States was apparent as early as 1861 when, at a time when the intentions of foreigners were seriously misunderstood in Japan, he stood guard with others night and day before the residence of Townsend Harris, the first Consul General of America in Japan.

Those were turbulent days in Japan, for among its people were many who bitterly censured the Shogunate for alleged blunders in the conduct of diplomatic affairs and who nursed intense hatred toward foreigners, and frequently resorted to violence. In January, 1861, Henry C. J. Heuskin, Mr. Harris' valued associate, was assassinated by rowdies. All the foreign ministers then in Japan, with the exception of Mr. Harris, blamed the Shogunate for its incompetency to protect them, and closed their legations and withdrew. Mr. Harris did not approve of this step and remained to attend to his duties. It was then that the guard was placed before his residence. Commenting on this action later, Viscount Shibusawa wrote: "The courageous and magnanimous attitude taken by Mr. Harris on this critical occasion made a strong appeal to the imagination of our people, who were now convinced of the genuineness of his sentiment toward them, and who from that moment began to put trust in America as a true friend of Japan."

His regard for the United States is revealed by the fact that he headed many of the Empire's delegations to American shores in the interests of friendship and economic exchange between the two nations. He was president of the American Relations Committee of Japan, and later became chairman of the American-Japan Society of Tokyo, similar to the organizations in the United States.

Viscount Shibusawa was made an honorary member of The American Society of Mechanical Engineers in 1929 during the visit of the American engineers to the World Engineering Congress at Tokyo. This was in recognition of the important part he had played in the industrial and economic development of the Japanese nation, his efforts toward the promotion of world understanding, and his support of and interest in physical and chemical laboratories and in all branches of engineering in Japan.

Even after he had reached an advanced age, Viscount Shibusawa continued his world travels, the last of his several visits to the United States being made in 1921 at the age of 81. Even then, though he had retired from many of his business connections, he was most active, rising at six or seven in the morning and working from twelve to fifteen hours a day. During his life he was president of more than seventy corporations, and for nearly three-quarters of a century was a trusted adviser of successive Japanese governments.

Viscount Shibusawa was born February 13, 1840, the son of an indigo merchant, in a small village near Edo, the present city of Tokyo. In his boyhood he received a thorough education in the Chinese classics and learned the art of the sword from the masterful Chiba. Going to Kyoto, then the capital, he entered the service of Lord Hitotsubashi, member of an influential branch of the Shogunate Tokugawa family. In 1867, a year before the downfall of the Shogunate, he was sent to France with Lord Bimbu, a brother of the reigning Shogun. When the Imperial Government was established in 1869 he was made a vice-minister in the Finance Department. Three years later he left the government service and began his great business career. One of his first acts was to establish the First National Bank, the pioneer national bank in Japan. He helped to found the Tokyo Chamber of Commerce, the Tokyo Bankers' Association, the Bankers' Clearing House, the Tokyo Stock Exchange, the Tokyo Marine Insurance Company, the great maritime firm Nippon Yusen Kaisha, and scores of other businesses of world-wide influence.

He was a leading figure in the organization of the Japan Mail Line and in the expansion of the nation's maritime efforts. The development of the cotton-spinning industry in Japan is largely due to his initiative, as well as other manufacturing enterprises such as silk weaving, hemp and rope mills, concrete plants, sugar refining, and affiliated projects of this modern age. In cooperation with government authorities he acted to improve Japan's natural production and resources by reclamation work and harbor construction, by improving agriculture to increase returns, and through the medium of introducing artificial fertilizers and high-grade cattle and stock breeding.

Early in the Meiji era, feeling that Japan's younger generation needed more facilities for commercial education, Viscount Shibusawa established a training school which became the forerunner of the present Tokyo Higher Commercial College. In charity movements his name almost always led all the rest. He was a leader in the establishment of the Tokyo Poor House and other charitable organizations. His promotion to the peerage in 1900 was in consideration of the immense service he had rendered to the country's commercial and industrial development, as well as to the cause of public welfare.

THE CARS OF 1932

Things Seen at the Recent National Automobile Show in New York

THIS year's exposition at the Grand Central Palace, New York, marked an important departure of the automobile industry from certain ideas held only a very few years ago. Of late the impression has been general among automobile engineers and leaders of manufacturing in that industry that the public now takes the engine and mechanism largely for granted, and bases its preference when buying cars on color, upholstery, beauty of line, and, as one man rather cynically expressed it, the allowance made for the old bus traded in at the time of purchase.

This year, however, the show was signalized by the marked attention given to mechanism, excellently illustrated by the presence of lecturers at several of the exhibits telling the public about the delights of automatic clutches and the mysteries of free wheeling.

FREE WHEELING

From a mechanical point of view the automobile of today is rapidly breaking its traditional connection with the car of yesterday.

Free wheeling, which was introduced for the first time into the American automobile market last year, has spread like wild-fire, until now it is used by practically every company—with the exception, however, of one large manufacturer of a popular low-priced car, which is not surprising in view of the great advantages which this device possesses, and several interesting modifications were exhibited. The employment of free wheeling has led to a further development—that of the automatic clutch—with the result that gear shifting has lost most of its terrors, especially for the novice in driving. In this connection reference may be made to another device which thus far has been introduced only on a small scale on buses, and that is the backslide lock, a contrivance that prevents a car from sliding backward unless the gear shift is in reverse. The convenience of such a device will be appreciated in starting a car up a hill, especially by those who have not acquired the knack of coordinating the brake and the clutch. Another novelty which seems to be finding favor with the automobile manufacturers is the so-called ride control, likewise for the first time introduced on an American car last year. By means of this device, which is actuated by a slight movement of a handle, the rigidity of hydraulic shock absorbers can be modified, with the result that their action can be adapted to the kind of the road over which the car is traveling.

OIL TEMPERATURE CONTROL

Oil temperature control is likewise being more widely used. Last year it was shown on but one make of car, while this year it appeared, in approximately the same design, on two other cars and a truck. In all of these the temperature control has been achieved by means of a discrete heat exchanger located at the engine block in which a stream of jacket water is passed over the lubricating oil. Another company claims to have achieved the same result by extending the water cooling to the bottom of the cylinder block and thus affecting the oil temperature.

Several other improvements have been brought out. One car is provided with means for changing the gear ratio on the rear axle, thus making it possible to conform the operation of the car to the kind of terrain—flat or hilly. The use of rubber mountings to eliminate the transmission of engine vibration to the chassis is likewise extending. This matter of vibration, it may be mentioned, is receiving more and more concentrated attention, the idea being to make the body as silent as possible. Until very recently there were so many other noises made by an automobile that the usual squeaks and groanings of the body did not attract attention. Today, however, the average engine runs so silently that other noises stand out. One of the sources of automobile noise and trouble is being now eliminated by a number of builders through the use of the silent second speed and synchromesh transmissions. These, together with free wheeling and automatic clutches, make it possible to shift gears at practically any speed, and form a valuable feature generally, and particularly when driving down steep and dangerous hills. On the other hand, the four-speed forward drive, which for a while seemed to bear promise of great expansion, did not show up conspicuously this year.

STREAMLINING

An interesting exhibit was made by the Reo Motor Car Company, which showed two models of automobiles, a conventional car, and a specially developed one, located in an air stream from a powerful fan. Tiny streamers showed the flow of air around the bodies—very smooth in the case of the specially designed car and highly turbulent in that of the conventional model. It has been stated that the new body shape was developed at the Aerodynamic Laboratories of the University of Michigan, which also did similar work for the Lincoln car. The statement was orally made at the show that at 70 mph the use of the new body results in a power saving of some 18 per cent. The same tests resulted in the development of a special shape of fender following what is known in aerodynamics as the tear-drop shape. Another modification of fender shape is provided by the Graham car, on which the fenders come well down over the wheels, covering the chassis, and differ somewhat from the conventional shape. The wheels themselves have been set two inches farther apart.

The supercharging device on the Franklin air-cooled car consists of a conduit which delivers some of the air from the engine-cooling fan to the carburetor at a pressure higher than atmospheric.

Those who are willing to write a fat check for a car of the utmost power and luxury have a wide range from which to choose, from the 265-hp Dusenberg priced at $16,500 to the 12's and 16's shown by Cadillac, Marmon, Lincoln, and Pierce-Arrow. All the cars shown, however, offer more powerful engines and greater possibilities of speed and comfort, and several provide as optional equipment high-compression heads which make it possible to develop a greater amount of power than the standard design with ordinary gasoline unmixed with special anti-detonants.

From an engineering point of view the show was very impressive, particularly in that it signified a return to the idea that the mechanical operating features of an automobile are as a sales point superior to a fortunate selection of color scheme and decorative gadgets.

BOOK REVIEWS AND LIBRARY NOTES

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the United Engineering Trustees, Inc., as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

America's Answer to the Russian Challenge

AMERICA'S ANSWER TO THE RUSSIAN CHALLENGE. By Robert Sibley. The Farallon Press, San Francisco, Calif., 1931. Cloth, $6^{3}/_{4} \times 10$ in., 172 pp., illus., $5.

THIS beautifully printed book has for its theme world power, and for its moral, world-power trend. Its author was one of many engineers who attended the World Power Conference in Berlin in 1930. The significance of this conference, and the testimony which its participants brought forward in praise of electrical power as a great force for civilization, are set forth in the first part of Mr. Sibley's book. A statement attributed to Lenin—"Communism is Sovietism plus electrification"—is quoted. It is shown how Western Europe might be covered by a gigantic network of electric transmission lines connecting its most important sources of power. This network, proposed by European engineers at the conference, would pass over national boundaries, and bring to the countries thus connected the advantages of participating in a generating and distributing system into which they might all pour whatever excess energy might be called for and from which they might draw their requirements whenever it became economical to do so. Such a network will be of economic and social advantage only as international good-will and mutual understanding exist. Electric power, says Mr. Sibley, thus emerges as a new common denominator among men, and Lenin's saying may be paraphrased to read, "Good-will plus electricity means World Peace."

Much had been heard at the Conference about the great electrical development at Dnieprostroy, built by an American engineer, and destined to develop 750,000 hp. From the Conference Mr. Sibley passed over into Russia and inspected this project. Six chapters, about 40 pages, are devoted to observations on the Russian experience. Mr. Sibley was not impressed by seeing sixteen thousand Russian workmen accomplish what five thousand American workers might have done without any more physical strain, and he comes to the conclusion that Dnieprostroy is great because it stands alone. In America or elsewhere it would be a giant among giants and its importance relatively dwarfed.

So Mr. Sibley returned to America with the warning that electrification was to be a decisive element in the success of the five-year plan, and found in the country of his birth, and particularly in his home state, California, ample evidence that electrification had accomplished such benefits for the people of the United States as Lenin had hoped would be accomplished by it for Communism. The future of "Electrified California" constitutes the second part of Mr. Sibley's book, which sets forth "the goal before the world in general and Russia in particular."

Part 3 contains America's answer. Measured by the electrification yardstick, Russia, says Mr. Sibley, will be far from overtaking the American program. He feels that there has been driven out of Russia much that is highly prized elsewhere—the church, freedom, individualism—and without which he doubts she will prevail. And it all comes down to this: "If the ultimate and final awakening of Soviet Russia is ever brought about, she will find herself . . . to all intents and purposes American to the core in education, in ideals of home, and above all, in the burning desire to press forward under the undying urge of the highest type of individual initiative."

Mr. Sibley's book contains five excellent appendices; some details of the 5-year plan relating to electrification; America's world status in the use of electric power; power resources of the world; Sir Arthur Eddington's World Power Conference paper on "Subatomic Energy;" and the address made by Albert Einstein at the same conference on "Space-Field and Ether Problems in Physics."—G. A. S.

Hydrodynamics and Aerodynamics

HYDRO- UND AERODYNAMIK (Handbuch der Experimentalphysik Vol. IV), edited by Professor L. Schiller, Leipzig. Part 1, Strömungslehre und Allgemeine Versuchstechnik (The Study of Flow and General Methods of Experiment). Published by Akademische Verlagsgesellschaft m.b.H., Leipzig, 1931. Cloth, $6^{3}/_{4} \times 9^{1}/_{2}$ in., 730 pp., 431 figs., 68 marks.

REVIEWED BY STARR TRUSCOTT[1]

THE third part of this fourth volume of the "Handbuch" of Experimental Physics[2] was devoted to the technical applications of hydro and aerodynamics, and comprised also detailed discussions of the research and experimental work which may be carried on in that field. We now have the first part of the volume with a series of discussions of the experimental methods to be used in the study of those parts of the fundamentals of the subject which may be included under the general term of the phenomena of flow. Naturally the experimental methods are discussed in parallel with the mathematical theories which apply.

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[1] Aeronautical Engineer, National Advisory Committee for Aeronautics, Hampton, Va.

[2] Reviewed by the present writer in MECHANICAL ENGINEERING, April, 1931, p. 319.

Like the part previously issued, the present one consists of a series of articles, or major sections, on different phases of the general subject. In the table of contents the title of each section, or article, is listed, and under each title the subject of each chapter and paragraph is given. The part of the table relating to each article is repeated at the beginning of the article.

There is no bibliography as such, all references being given as footnotes on the pages where they are mentioned. However, the same care has been shown in the preparation of the index by names and another by subjects as in the earlier volume. Complete indexes to all three parts of this volume are promised for Part 2 when issued.

In Part 2 are to be considered the problems of resistance and related phenomena. This assurance helps one to understand why references to frictional drag and resistance in general are relatively few in the present section of the work. But for this information one might feel that disproportionate emphasis was being given to special types of flow, such as that around a sphere.

About half of the authors of the eleven major sections into which the work is divided place "Göttingen" after their names. This may give undue emphasis to the ideas of the "Göttingen School," but it certainly has led to well-related treatment of the subjects of the different articles.

The first section, very appropriately, is by Dr. Prandtl, and is an introduction to the fundamentals of the theory of flow. Within its 40 pages the author passes swiftly over the whole field, touching on some point of almost every one of the succeeding articles and showing it as a fundamental part of the general subject and related to the whole. The clearness and simplicity of this section make it one to be remembered with the greatest pleasure.

The second section, of about 200 pages, is a review of classical hydrodynamics by H. Falkenhagen, of Köln. The first chapter of this section takes up the dynamics and kinematics of fluids, and the second, the dynamics of special states of flow. The first chapter follows quite conventional lines in summarizing the mathematical treatment of its subject with the various equations and expressions which have been derived to express the relations between the quantities of interest in a flow.

In the second chapter particular attention is paid to vortex theories, potential flows, and flow around spheres and airfoils. Three particularly interesting subsections or paragraphs by H. Schmiedel, of Leipzig, are included in this chapter. One is devoted to experiments with pulsating and oscillating spheres, following a theoretical study of the subject as an example of potential flow. This recalls the delightful demonstrations of some of these phenomena given by Dr. Bjerknes in Washington some years ago. The second discusses experiments with vortex rings and includes many data in a brief compass. The last follows the theoretical consideration of Karman's "Vortex Street" by a discussion of experimental methods, and thus makes the consideration of this subject much more complete.

The third section, by W. Tollmien, of Göttingen, comprises about 50 pages and is devoted to the theory of the boundary layer. The boundary-layer equations are first derived according to the method devised by Prandtl, and in subsequent chapters the discussion is carried on to stationary and moving boundary layers.

The succeeding section, on turbulent flow, is also by Tollmien, and includes among other subjects those of the structure of turbulent flow, equations for its mean value, and the surface friction of turbulent flow. There is frequent reference to the earlier section in this and the preceding one. The experimental point of view becomes more prominent in this section than in the two preceding ones.

The section on gaseous dynamics, by A. Busemann, Göttingen, is an important one, occupying about 120 pages, and is divided into six subsections or chapters. These deal, respectively, with the theory of gaseous dynamics, flow in pipes, nozzles and diffusers, plane flow, measurements in wind tunnels, and moving bodies. With this section the experimental side of the subject assumes the dominant position. The experimental approach and the results obtained therefor are brought clearly into the mind of the reader. The arrangement and use of various devices employed in the experimental work are described and illustrated, such as the "Schlieren" apparatus for studying high-velocity flow, and high-speed wind tunnels for generating the high-velocity flow.

The section on cavitation, by J. Ackeret, of Zurich, is relatively short and condensed. It consists of only 20 pages and begins with a general consideration of the problem. Some of the splendid cavitation pictures obtained by the author in his own work at Göttingen are shown in connection with the experimental study, while a discussion of the mechanics of corrosion due to cavitation forms the closing chapter.

The subject of pressure measurements is divided between two sections of about 20 and 35 pages, respectively. In the first, by H. Peters, of Göttingen, we find a discussion of the methods of constructing and arranging equipment which will develop the correct pressures at the points under investigation, while the second, devoted to micromanometers, by A. Betz, of Göttingen also, discusses the various instruments to be used to indicate the pressure after suitable connection between the pressure-receiving apparatus and pressure-indicating device has been made.

The section on the measurement of the velocity and volume of fluids, by H. Mueller and H. Peters, of Göttingen, occupies about a hundred pages. It begins with descriptions of methods for using floats and pilot balloons to determine velocities, and ends with chemical methods for determining volumes. Between these paragraphs there are passed in review and illustrated practically all of the available devices for both purposes. Different types of current meters, anemometers, and the like are shown. The venturi meter is described and illustrated, together with devices using calibrated nozzles and throttling orifices. Curves showing the characteristics of these devices are included. Weirs and devices for measuring water by weighing are followed by gasometers and by gas meters. In a relatively short space the author has made available the most needed data regarding a whole category of equipment.

The succeeding chapter, on hot-wire measurements, by J. M. Burgers, of Delft, was completed, according to a note by its author, in April, 1928. Since that date the work of Drs. Dryden and Kuethe, published in Technical Reports Nos. 320 and 342 of the National Advisory Committee for Aeronautics, had added much to the accuracy of this type of equipment. However, the principles and general types of construction are well described, while the literature of the subject is given such extensive reference that the 30 pages of the article have nearly 60 references.

The last section, by O. Tietjens, of the Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa., is entitled "Observation of Flow Patterns." Possibly a better idea of the contents and a more truthful rendering of the original thought might be given if it were called "Methods for the Visualization of Flow." Here are described in brief but adequate manner the difficulties attendant on making apparent to the eye the paths in which the particles of a fluid move in any change from a simple "parallel" flow. As is explained, this requires resort to photography. Methods are described and illustrated in which camera, fluid, and disturbing object are moved together, or separately, in various manners, and in which two-dimensional or three-dimensional flow is observed and recorded. A generous number of flow patterns obtained in different ways are shown. The section concludes with a brief discussion of the photographic factors of background, films, and printing papers.

This part of the fourth volume of the "Handbuch" contains much of the theoretical and mathematical treatment of its subjects, but the emphasis on the experimental side is strong and sustained throughout. Although somewhat condensed, the language is uniformly clear and explicit. The book will prove of great value to any who have to do with the experimental study of the subjects which it covers.

Books Received in the Library

ARCHIV FÜR TECHNISCHES MESSEN, ATM, EIN SAMMELWERK FÜR DIE GESAMTE MESSTECHNIK. Edited by G. Keinath. Munich and Berlin, R. Oldenbourg. Lieferung 1, 2, 3, July, August, September, 1931. Paper, 8 × 12 in., illus., diagrams, charts, tables, 2 r.m. each.

These are the first numbers of an encyclopedia of measuring instruments and methods, which is to be published in parts over a period of five years, and aims to provide a convenient, up-to-date reference work for engineers, chemists, and physicists. The articles are so arranged that they may be classified in loose-leaf binders, a decimal classification being provided for each article. The work aims to bring together the material in this field which now is scattered through many publications.

AVIATION ENGINES. By R. F. Kuns. American Technical Society, Chicago, 1931. Cloth, 6 × 9 in., 198 pp., illus., diagrams, charts, tables, $2.

The characteristics, operation, and maintenance of a number of typical modern engines are described in the book, which is intended for the airplane-engine mechanic. The treatment is concise and practical.

BALANCING OF MACHINERY. By C. N. Fletcher. Emmott & Co., London, 1931. Cloth, 6 × 9 in., 172 pp., illus., diagrams, charts, tables, 10s. 6d.

The balancing of high-speed machinery is here discussed from the point of view of the production engineer, not from that of designer. The book summarizes the factors that affect balance, describes the better-known apparatus for detecting unbalance, and the methods and calculations involved in correcting bodies that are shown by this apparatus to require it. The treatment is entirely a practical one.

CONSTRUCTION MÉCANIQUE. By J. Izart. 51st edition. Dunod, Paris, 1932. Leather, 4 × 6 in., 494 pp., illus., diagrams, charts, tables, 20 fr.

A concise pocket-book for mechanical engineers, containing formulas, tables, and information on mechanics, machine tools, transmission, hoisting apparatus, and similar subjects which is frequently wanted in practice.

DARSTELLUNG DER GESAMTEN SCHWEISSTECHNIK. By P. Bardtke. 2nd edition. V.D.I.-Verlag, Berlin, 1931. Cloth, 6 × 8 in., 275 pp., illus., diagrams, charts, tables, 12.50 r.m.

A concise, yet comprehensive survey of methods of welding, welding appliances, welding practice, testing methods, etc. The entire field is covered in simple, practical fashion, the book being adapted to use as a textbook and as a convenient work of reference.

DYNAMISCHE UNTERSUCHUNGEN DES FRÄSVORGANGES. (Berichte über betriebswissenschaftliche Arbeiten, Band 7.) By F. Eisele. V.D.I.-Verlag, Berlin, 1931. Paper, 8 × 12 in., 41 pp., illus., diagrams, charts, tables, 11 r.m.

A study of the causes of "chatter" of milling cutters and of methods for its prevention. Testing apparatus and tests are described by which the kind, magnitude, and time sequence of the fluctuations in cutting pressure, which cause chatter were measured. The results of tests upon different materials at various feeds, cutting speeds, and cutting depths are given, and rules derived for combating and preventing vibration. The data are of use to builders and users of milling machines.

EARLY FORGES AND FURNACES IN NEW JERSEY. By C. S. Boyer. University of Pennsylvania Press, Philadelphia, 1931. Cloth, 6 × 10 in., 287 pp., illus., maps, $5.

This work presents a great amount of data upon early ironmaking in New Jersey which has heretofore been widely scattered or unknown. The history of over one hundred forges and furnaces is recorded as fully as possible. An important item is the record of the bog-iron industry of southern New Jersey, about which little has been known until now. The book is the result of much patient research in contemporary newspapers, deeds, wills and other manuscripts, and is a valuable addition to the history of the American iron industry.

FARADAY AND HIS METALLURGICAL RESEARCHES. By Sir R. A. Hadfield. Chapman & Hall, Ltd., London, 1931. Cloth, 6 × 10 in., 329 pp., illus., diagrams, charts, tables, 21 s.

It will surprise many, who think of Faraday chiefly as the discoverer of electromagnetic induction, to learn that he was also the first to conduct systematic researches upon alloy steels and that his work, far in advance of the demand of his day, was not only valuable but is still of great interest. Happy chance has enabled Sir Robert Hadfield to investigate thoroughly, by modern methods, a large number of alloys which Faraday made and packed away over a century ago. These entitle Faraday to credit as the pioneer student of alloy steels and show the remarkable work that he did from 1819 to 1824, when his efforts in this field were discontinued. Sir Robert tells the story in detail in this handsomely illustrated, readable volume. The circumstances under which Faraday worked and the men associated with him are described. The modern investigations and their results are given fully. The history of the development of alloy steels since Faraday is reviewed. The book is a valuable addition to the history of metallurgy which every metallurgist will find of interest.

INDUSTRIAL HYGIENE for Engineers and Managers. By C. P. McCord, assisted by F. P. Allen. Harper & Brothers, New York and London, 1931. Cloth, 6 × 10 in., 336 pp., illus., diagrams, maps, charts, tables, $5.

A handbook on all phases of the preservation of life in industry, in which the latest methods of disease and accident prevention are discussed from the points of view of the physician and the executive. The work is intended especially for engineers and managers of industries who are responsible for the health and safety of employees. They will find much valuable help in this book.

An Acknowledgment

THE picture on the cover of the February issue of MECHANICAL ENGINEERING, and those in Professor Pound's article on "Pipe-Line Transportation" on pages 104, 105, and 106 of the same issue, were obtained through the courtesy of the A. O. Smith Corporation of Milwaukee, Wis.

CURRENT MECHANICAL ENGINEERING LITERATURE

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ACCELEROMETERS

Theory. Ueber Beschleunigungsmessungen (Measurements of Acceleration), J. Geiger. Mitteilungen aus den Forschungsanstalten, vol. 1, no. 7, Oct. 1931, pp. 162–174, 23 figs. Method of measuring acceleration directly instead of indirectly by means of path-time curve; theory of instruments for constant direct registration of acceleration-time curve; theoretical mathematical study and results of practical measurements.

AIR COMPRESSORS

Rotary. S.L.M. Portable Rotary Compressors. Engineerng, vol. 132, no. 3439, Dec. 11, 1931, p. 741, 4 figs. Compressors manufactured by Swiss Locomotive and Machine Works, Winterthur, Switzerland, are claimed to be markedly more silent than more usual reciprocating units and possess other advantages.

AIRPLANE ENGINES

Design. Om flygmotorer och defas beralkning och konstruktion (Calculation and Design of Airplane Engines), H. Jyrklund. Tekniska Foereningens i Finland Foerhandlingar, vol. 51, nos. 7 and 11, July 1931, pp. 201–210 and Nov., pp. 357–363, 11 figs. Thermodynamic calculations, design of combustion chamber, etc.; current practice in design of pistons, valves, piston pins, etc.

Exhibitions. Les moteurs français du dernier Salon (French Engines at Paris Exhibition), P. Leglise. Aeronautique, vol. 13, no. 141, Feb. 1931, pp. 49–58, 33 figs. Performance data and design of principal French makes including Farman, Gnome-Rhone, Hispano-Suiza, and Lorraine.

Fuel Pumps. Nouvelles pompes à essence (New Fuel Pumps). Aéronautique, vol. 13, no. 145, June 1931, pp. 224–228, 16 figs. Design and operation of representative types utilizing diaphragms, vanes, and pistons, built by Fiat, Junkers, and A. M. companies.

Jacobs. Technical Description of Jacobs L-3 Aircraft Engine, L. R. Parkinson. Aviation Eng., vol. 5, no. 5, Dec. 1931, pp. 23–25, 7 figs. Three-cylinder radial air-cooled engine developing 55 hp at 2125 rpm, with bore and stroke of 4.13 by $4^3/_4$ in.

Junkers Diesel. Junkers Heavy-Oil Engine for Aeroplanes. Mech. World, vol. 90, no. 2338, Oct. 23, 1931, pp. 406–409, 6 figs. Chief advantages to be gained by applying heavy-oil engines to aircraft, and description of Junkers motor.

Supercharging. Exposé pratique du probléme de la suralimentation des moteurs d'avions (Practical Survey of Problems in Supercharging Airplane Engines), C. Waseige. Technique Aéronautique, vol. 22, nos. 113, 114 and 116, Mar. 1931, pp. 71–76, Apr., pp. 99–105 and June, pp. 142–151, 23 figs. Necessity of supercharging for improving performance; comparison of different types of compressors; modifications required on engine units, with special regard to carburetors, magnetos, propellers, etc.

AIRPLANES

Brakes. Hydraulic Brakes for Aircraft, R. Waring-Brown. Aircraft Eng., vol. 3, no. 34, Dec. 1931, pp. 301–304 and 318, 19 figs. Theoretical and practical qualities with descriptions of prominent examples, particularly Lockheed, De Lavaud, Vickers, and Timken.

Les nouveaux systèmes Charlestop de transmission et de freinage (New "Charlestop" Remote Brake Transmission and Control), P. Leglise. Aéronautique, vol. 13, no. 146, July 1931, pp. 261–263, 12 figs.; see also translation in Nat. Advisory Committee Aeronautics—Tech. Memo., no. 640, Oct. 1931, 3 pp., 12 figs. on supp. plate. Design of hydraulically operated brake with differential braking action.

Control. Automatische Flugzeugsteuerungmittels Kreiselgeraeten (Automatic Airplane Control by Means of Gyroscope), F. V. Lindner. Zeit. fuer Flugwesen, vol. 11, no. 8, 1931, pp. 115–119, 5 figs. Principles of design and operation of different makes, with particular regard to Boykow, Marmonier and Askania automatic pilots.

Recherches et expériences sur le pilotage automatique (Research and Experiences With Automatic Control), Etévé. Aéronautique, vol. 13, no. 143, Apr. 1931, pp. 117–121, 9 figs. Various arrangements for automatic operation of control surfaces, with particular regard to stabilizing in turbulent air.

Design. Beitrag zur Entwicklung eines autorotationsfreien steil landbaren Flugzeuges (Development of Non-Autorotative Airplane Capable of Steep Landing), W. Schmidt. Zeit. fuer Flugtechnik und Motorluftschiffahrt, vol. 22, nos. 18 and 19, Sept. 28, 1931, pp. 546–549 and Oct. 14, pp. 569–578, 32 figs.; see also translation in Nat. Advisory Committee Aeronautics—Tech. Memo., no. 650, Dec. 1931, 26 pp., 32 figs. on supp. plates. Experimental and theoretical investigation of autorotation characteristics of different monoplane wings.

Helicopters. See *Helicopters.*

Materials. See *Glucinum Alloys.*

Passenger. German Transport Airplanes—VI, E. P. A. Heinze. Aero Digest, vol. 19, no. 6, Dec. 1931, pp. 57–59, 7 figs. Twin-engined Do. J "Wal" Seaplane; 22-passenger Do. S. with four Hispano Suiza 640-hp engines; 8-passenger all-metal "Merkur" with 600-hp B.M.W. engine; Dornier Do. K land plane with four 240-hp engines.

Performance Calculation. Calcul de la vitesse d'atterrissage d'un avion a partir de ses caracteristiques aerodynamiques et de la vitesse verticale a l'atterrissage, R. Pouit. Aeronautique, vol. 13 no. 150, Nov. 1931, p. 385–386. Calculation of landing speed of airplane on basis of aerodynamic characteristics and vertical landing speed; derivation of formula with numerical example.

Propellers. Il calcolo indiretto delle eliche (Indirect Calculation of Propellers), U. de Caria. Aeronautica, vol. 5, no. 9, Sept. 1931, pp. 623–627, 5 figs. Development of graphic methods for determining aerodynamic characteristics of various types of propellers.

L'adaptation de l'helice à l'avion (Adaptation of Propellers to Airplane), J. Volpert. Technique Aéronautique, vol. 22, nos. 111 and 113, Jan. 1931, pp. 21–25 and Mar., pp. 60–70, 11 figs. Fundamental consideration in selecting propellers for best operating conditions, with particular regard to engine output; graphical representation of factors controlling efficiency and propellers.

L'hélice "roue-libre" Paulhan-Pillard pour l'amélioration du vol avec moteur arreté, Paulhan-Pillard (Free-Wheel Propeller, for Improving Flight With Stalled Engine), M. Pillard. Aéronautique, vol. 13, no. 146, July 1931, pp. 245–252, 23 figs. Design and operating characteristics of propeller hubs incorporating roller clutches; tables give data on improved performance due to decreased drag.

Shock Absorbers. Dynamische Untersuchung von Flugzeugfederbeinen (Dynamic Investigation of Airplane Shock Absorbers, P. Langer and W. Thome. V.D.I. Zeit., vol. 75, no. 45, Nov. 7, 1931, pp. 1388–1389, 12 figs. Measurement of vertical impact with different types of shock absorbers on drum-testing equipment; different damping systems of liquid, steel-spring, and rigid types.

Wing Flutter. Wing Oscillation, A. E. Parker. Flight, vol. 23, no. 48, Nov. 27, 1931, pp. 1174a–1174c, 6 figs. Mathematical investigation of two cases: (1) only spars are considered, effect of bracing entirely omitted, except as regards weight of wing; (2) elliptic distribution of pressure over span modified due to tapering of wings; center section of wings to have no lift.

ALCOHOL FUEL

Czechoslovakia. "Dynalkol," carburant national de la Republique Tchecoslovaque (Dynalkol, National Fuel of Czechoslovakian Republic), E. Kostuk. Assn. des Chimistes de Sucrerie—Bul., vol. 48, no. 10, Oct. 1931, pp. 408–415. Fuel is mixture of 50 per cent alcohol of 96.6 deg purity, 30 per cent gasoline, and 20 per cent benzol.

ALLOY STEELS

Cromansil. A Low Alloy Steel for Large Tonnage Applications, A. B. Kinzel. Iron Age vol. 128, no. 27, Dec. 31, 1931, pp. 1686–1688, 3 figs. Physical properties of typical Cromansil steels containing chromium, manganese, and silicon; comparison of Cromansil and other steels.

ALLOYS

Aluminum. See *Aluminum Alloys.*

Bearing Metals. See *Bearing Metals.*

Glucinum. See *Glucinum Alloys.*

ALUMINUM

Rolling. Metal Lubrication and Roll Cooling in Aluminum Hot-Mill Practice, R. J. Anderson. Iron Age, vol. 128, no. 27, Dec. 31, 1931, pp. 1674–1677, 2 figs. Problems encountered in rolling aluminum and aluminum-alloy sheet ingots; lubricants used, such as kerosene, light machine oil, greases, and water-oil mixtures; practice of some American and European plants.

ALUMINUM ALLOYS

Castings. High-Strength Sand-Casting Aluminium Alloys, W. C. Devereux. Foundry Trade Jl., vol. 45, nos. 797 and 798, Nov. 25, 1931, pp. 331–335 and Dec. 3, pp. 349–351 and (discussion) 351–352, 21 figs. Subject is confined to alloys now used extensively for highly stressed or special parts, such as "Y" alloy, R. R. alloys, and 4 per cent copper alloys; competition from crop forgings; casting properties and elimination of chills. Before Inst. Brit. Foundrymen.

Machining. Werkzeugmaschinen fuer Leichtmetallbearbeitung (Machine Tools for Light Metals), P. Kelle. Zeit. fuer Metallkunde, vol. 23, no. 11, Nov. 1931, pp. 309–313, 12 figs. Tungsten-carbide tools have proved most suitable for drilling light metals containing silicon; for other aluminum alloys, high-speed tool steels suffice; special types of machine tools; machining of light-metal pistons.

AUTOMOBILE ENGINES

Diesel. See *Diesel Engines* (Automotive).

AUTOMOBILES

Brakes. Momentum-Boosted Braking System Gives Accurate Stop, P. M. Heldt. Automotive Industries, vol. 65, no. 26, Dec. 26, 1931, pp. 988–991, 6 figs. Mechanical features are embodied in four wheel, mechanical, power-actuated braking system recently announced by Stewart-Warner Corp., Chicago.

Design. Beschouwingen over de nieuwste automobiel-constructies (Considerations of Latest Automobile Designs), A. Van der Mee. Polytechnisch Weekblad, vol. 25, nos. 38, 39, 40, 41, and 43, Sept. 17, 1931, pp. 593–595, Sept. 24, pp. 612–614, Oct., pp. 630–632, Oct. 8, pp. 643–645 and Oct. 22, pp. 678–680 and 682, 18 figs. General review of improvements in European and American representative makes of passenger cars and engines.

Transmissions. Hobbs Gearless Drive, W. G. T. Goodman. Commonwealth Engr., vol. 19, no. 4, Nov. 2, 1931, pp. 149–151, 2 figs. Gearless drive invented by H. F. Hobbs, of Adelaide, South Australia, has three essential elements: weighted gears to produce forces, roller clutch to prevent motion, and torsional spring to transmit drive.

New Four-Speed Gear Box. Automobile Engr., vol. 21, no. 288, Dec. 1931, p. 589, 2 figs. Design with constant-mesh second- and third-speed gears by Laycock Engineering Co., Sheffield, England.

Transmission, L. H. Pomeroy. Automobile Engr., vol. 21, no. 288, Dec. 1931, pp. 596–600, 5 figs. Desirable attributes of motor-vehicle transmission and tèchnical description of Daimler fluid-flywheel transmission.

AUTOMOTIVE FUELS

See *Alcohol Fuel; Coal* (Liquefaction).

BALANCING MACHINES

Dynamic. Hoffman-Kunze Dynamic Balancing Machine. Automobile Engr., vol. 21, no. 288, Dec. 1931, pp. 590–591, 3 figs. Design and operating principles; amplitude of vibration is inscribed by pointers on charts in front of machine.

BEARING METALS

Behavior. Die Lagermetalle und ihr Verhalten im Betriebe, R. Kunze. Maschinenbau, vol. 10, no. 21, Nov. 5, 1931, p. 664–670. Bearing metals and their behavior in operation; directions for selection; fundamental characteristics; testing with special regard to methods and testing equipment used by German State Railroad; test results; behavior of metals used; bearing of railroad cars. Bibliography.

Porous Bronze. Coussinets en bronze poreux, système Compo (Bearing of Porous Bronze Compo System). Génie Civil, vol. 98, no. 16, Apr. 18, 1931, p. 404, 2 figs. New type of bearing made with porous bronze allows bearing metal to become saturated with oil, 25–30 per cent of oil being absorbed by wall of bearing.

BOILER FEEDWATER

Analysis. Chemical Analyses in Embrittlement Studies. Power Plant Eng., vol. 35, no. 23, Dec. 1, 1931, pp. 1136–1140, 1 fig. Laboratory analysis shows that Am. Public Health Assn. and modified Winkler methods give reliable results when used on boiler waters for embrittlement studies; phosphates and silicates present.

Die Abloesung des Begriffes und der Masszahl Haerte in der Dampfkessel-Speisewasserpflege (Change in Interpretation and Unit of Hardness in Boiler-Feedwater Treatment), A. Sulfrian. Waerme, vol. 54, nos. 51–52, Dec. 19, 1931, pp. 954–957. By introduction of term, "ballast material," and designation of chemically pure materials with usual terms and with use of internationally accepted milliunit, author has effected standardization in feedwater-treatment practice.

Hydrogen Ion Concentration. Hydrogen Ion Determinations in Steam Plant, C. E. Joos. Combustion, vol. 3, no. 4, Oct. 1931, pp. 25–30, 39 and 46, 6 figs. Factor of hydrogen ion concentration, commonly referred to as pH value, with reactions involved and their significance; instruments are available which make determination of pH value comparatively simple matter; significance of pH value in connection with boiler waters of various characteristics and when using various methods of feedwater treatment.

BOILERS

Automatic Control. Electro-Automatic Draft Control for Steam Boilers, G. H. Logan. West. Gas, vol. 7, no. 12, Dec. 1931, pp. 23 and 57, 3 figs. Object of system described is to adjust air supply equipment for gas- and oil-fired boilers to optimum position simultaneous with change in burner pressure.

Design. Trend in Boiler Development Toward Simplicity, R. C. Roe. Power Plant Eng., vol. 35, no. 24, Dec. 15, 1931, pp. 1174–1176, 1 fig. Development of high single-pass inclined-tube boiler, units with capacities considerably over 1,000,000 lb of steam per hr, and fluid air heaters are some of year's contributions to boiler-plant design; water treatment; stokers and pulverizers; air heaters.

Firing. Wanderrost oder Staubfeuerung (Traveling-Grate or Pulverized-Coal Firing), H. Bleibtreu. V.D.I. Zeit., vol. 75, no. 44, Oct. 31, 1931, pp. 1358–1360. Reasons for different valuation of two systems in Germany and United States; critical comparison with regard to efficiency, control, reliability, fuel feed, operating expenses, etc.

Furnaces. Erfahrungen mit scheitrechten Gewoelben bei Wanderrosten (Experiences With Flat Arches in Traveling-Grate Furnaces), H. Roentsch. Waerme, vol. 54, no. 51–52, Dec. 19, 1931, pp. 957–959, 10 figs. Results of tests on suspended-roof type of boiler furnace.

Temperaturverhaeltnisse in den Brennkammern Kurzflammiger Kohlenstaubfeuerungen mit wassergekuehlten Waenden (Temperature Conditions in Combustion Chambers of Short-Flame Furnaces With Water-Cooled Walls), E. Eckert. Waerme, vol. 54, no. 50, Dec. 12, 1931, pp. 915–919, 6 figs. Mathematical investigation, with special regard to influence of burning time, air preheating, and load, and of type of coal on flame temperature and temperature drop of burnt gases up to entry into contact heating surface.

High-Pressure. Considerations sur la chaudiere Loeffler a haute pression au point de vue de la construction (Loeffler High-Pressure Boiler From Design Viewpoint), Rochel. Chaleur et Industrie, vol. 12, no. 138, Oct. 1931, pp. 537–546, 25 figs. Design of superheaters; process of steam generation; water level indicator; accessories; new designs; heating.

Marine Critical-Pressure Boiler. Power, vol. 74, no. 24, Dec. 15, 1931, pp. 870–872, 3 figs. Design and constructional features of Benson 3200-lb boiler on Hamburg-American liner "Uckermark;" section through Benson boiler; operating features.

Purdue High-Pressure Boiler, A. A. Potter, G. A. Hawkins, and H. L. Solberg. Power, vol. 74, no. 22, Dec. 1, 1931, pp. 798–801, 5 figs. Desirability of exploring field up to critical pressure is such that both Purdue University and Yarnall-Waring Co. have installed units designed to be operated in tests over this range; features of Bailey power-type pressure gage; diagram of testing equipment; measurement of pressures and temperatures.

Water Circulation in Boilers. Power Engr., vol. 26, no. 308, Nov. 1931, pp. 427–430, 6 figs. Review of research conducted by Sulzer Bros., Ltd.; side sectional elevation of special extra-high-pressure Sulzer boiler; curves of test results.

Locomotive. See *Locomotives* (Boilers).

Plates—Testing. De l'essai au choc barreaux entaillés (Impact Testing of Notched Bars and Its Application to Acceptance of Boiler Plates), V. Kammerer. Associations Françaises de Propriétaires d'Appareils a Vapeur—Bul., no. 46, Oct. 1931, pp. 213–248, 26 figs. Method, test equipment, tests, and analysis.

Pulverized-Coal-Fired. Verbrennung von ungemahlenem Kohlenstaub in Kohlenstaubfeuerungen (Combustion of Unpulverized Coal Dust in Pulverized-Coal Furnaces), O. Haller. Glueckauf, vol. 67, no. 43, Oct. 24, 1931, pp. 1348–1352, 3 figs. Pulverized-coal furnace developed at Stinnes mines, uses unpulverized dust up to 3-mm grain size with good boiler output, and practically complete combustion; cooling-water grate is eliminated and lower part of furnace is completely sealed with brick slabs having perforations for air entry.

Water-Tube. Boiler Plant at Harrogate Power Station. Engineering, vol. 132, no. 3439, Dec. 11, 1931, p. 740. Boilers were constructed by Yarrow and Co., and are of firm's S.F.I. type; each has normal evaporation of 50,000 lb per hr; working pressure is 350 lb per sq in., final steam temperature being 730 deg; all boiler tubes are straight and are $1\frac{3}{4}$ in. in external diam.; each boiler is fitted with two mechanical stokers.

Die Strahlung des Rostes in einem Wasserrohrkessel (Radiation From Water-Tube Boiler Grates). Werft-Reederei-Hafen, vol. 12, no. 21, Nov. 1, 1931, pp. 359–363, 8 figs. Attempt is made to place radiation problem upon scientific basis; investigation was carried out by Sulzer Bros.; theory developed is applied to numerical investigation.

Spannungen in Rohrplatten von Wasserrohrkessein (Stresses in Tube Plates of Water-Tube Boilers), K. Baatz. Waerme, vol. 54, nos. 51–52, Dec. 19, 1931, pp. 930–934. It is claimed to be entirely possible to calculate individual stress-forming influences and effect of internal pressure; rules for calculation, based on recent literature and work of Kammerer and Parmentier.

BOLTS AND NUTS

Heat Treatment. Heat Treatment of Bolts Has Improved Modern Engineering Practice, F. O. Kichline. Heat Treating and Forging, vol. 17, no. 11, Nov. 1931, pp. 1042–1045, 3 figs. Production methods and equipment at Lebanon plant of Bethlehem Steel Co., with particular regard to heat treatment; physical properties of steel.

BORING MACHINES

Jig. Die Herstellung Genauer Lochabstaende in Bohrlehren (Production of Accurate Hole Distances in Boring Templets), F. Kleinpeter. Werkstattstechnik, vol. 25, no. 13, July 1, 1931, pp. 321–324, 7 figs. Economies and improvements in accuracy obtained by modern equipment; operation of boring machines by J. E. Reinecker, Chemnitz, H. Hauser A.-G., Pratt and Whitney, Hartford, and Keller Mechanical Engineering Corp., Brooklyn.

BORING MILLS

40-Ft Mill. 40-Ft Boring and Turning Mill. Engineering, vol. 132, no. 34–39, Dec. 11, 1931, pp. 738–739, 3 figs. Machine made by Etablissements Charles Berthiez, Paris, is stated to be largest of its type in world, and is designed to turn work up to 40 ft in diam.

CABLES

Wire-Testing. Drahtseilforschung (Wire Cable Research), R. Woernle. V.D.I. Zeit., vol. 75, no. 49, Dec. 5, 1931, pp. 1485–1489, 21 figs. Abstracts of papers presented at session of committee on wire cable research of Verein deutscher Ingenieure; testing and lubrication of various types of wire cables, with particular regard to data obtained at Technical University of Stuttgart.

CAR AXLES

Suspension. Untersuchungen ueber die Eigenschaften der Peckham-Aufhaengung (Investigation of the Properties of Peckham Suspensions), H. Paulsmeier. Verkehrstechnik, no. 35, Aug. 28, 1931, pp. 423–427, 9 figs. Movements of Peckham axles in relation to cars; comparison of sideward vibrations and those resulting from flange friction in curves for cars with and without Peckham suspensions.

CASE-HARDENING

Carburizing. Energizing Action of Various Chemicals in Carburization of Steel With Solid Carburizing Agents, R. A. Ragatz and O. L. Kowalke. Metals and Alloys, vol. 2, no. 5, Nov. 1931, pp. 290–296, 4 figs. Numerous compounds of sodium, potassium, barium, and calcium were employed for comparison with carbonates of respective elements at various concentrations, temperatures and times for carburization; research at University of Wisconsin.

Mechanism of Energizer Action in Carburization, R. A. Ragatz and L. O. Kowalke. Metals and Alloys, vol. 2, no. 6, Dec. 1931, pp. 343–348, 4 figs. Interpretation of experiments shows that energizing action exerted by certain chemicals in carburization of steel primarily due to catalytic effect produced on $C:CO_2:CO$ reaction; review of previous theories.

CAST IRON

Alloy. Alloy Cast Irons, G. S. Bell. Foundry Trade Jl., vol. 45, nos. 798 and 799, Dec. 3, 1931, pp. 353–354 and Dec. 10, pp. 365 and 368, 2 figs. Effects of adding to ordinary gray cast-iron mixture, various proportions of metallic elements; nickel in gray cast iron; chromium additions; austenitic cast iron. Before Inst. Brit. Foundrymen.

Heat Treatment. Recherches sur la trempe martensitique et le traitement thermique durcissant des fontes (Researches on Martensitic Hardening and Hardening by Heat Treatment of Cast Iron), L. Guillet, J. Galibourg, and M. Ballay. Revue de Métallurgie, vol. 28, no. 11, Nov. 1931, pp. 581–597, 24 figs. Investigations to determine composition of special cast irons, best suited to heat-treating processes; influence of treatment on hardness and other mechanical properties; microstructure; applications of martensitic cast iron. Before Int. Congress for Safety in Aviation, Paris.

High-Quality Pig for. "Migra" Iron, New Special Pig-Iron for High-Quality Casting, E. Piwowarsky and A. Wirtz. Foundry Trade Jl., vol. 45, no. 792, Oct. 22, 1931, pp. 251–252 and 254, 2 figs. As new pig iron is characterized by fine-graphite grain and fracture, it is called "Migra" Iron (micro-graphite); results of melting tests in foundry of Vereinigte Stahlwerke A.-G., Muelheim-Ruhr, where Migra iron with low phosphorus content is produced.

CASTINGS

Temperature Effect. Considerations and Tests for Cast Materials for High-Temperature, High-Pressure Service, L. W. Spring. Am. Foundrymen's Assn.—Trans. and Bul., vol. 2, no. 10, Oct. 1931, pp. 13–55, 24 figs. Properties of castings as compared to forged and welded materials; they are stiffer and more resistant to creep at temperatures above strain-hardening range (1000 F); they seem more resistant to corrosion, etc.; factors in development of materials for high-temperature, high-pressure service.

CHROMIUM-NICKEL STEEL

Fabricating. Methods Used in Fabricating Allegheny Metal. Machy. (N. Y.), vol. 38, no. 4, Dec. 1931, pp. 244–246. How to obtain best results in fabrication of 18–8 chrome-nickel alloys including such operations as turning, grinding, drilling, and punching; recommended pickling methods.

Hardening. Die Verguetung eines hochlegierten austenitischen Chrom-Nickel-Stahls durch Ausscheidungshaertung (Treatment of Highly Alloyed Austenitic Chromium-Nickel Steel by Dispersion Hardening, E. Greulich. Archiv fuer das Eisenhuettenwesen, vol. 5, no. 6, Dec. 1931, pp. 328–330, 16 figs. Review of earlier research; composition and pretreatment of investigated steels; influence of carbide separation on mechanical properties; high-temperature resistance; solubility in acids.

COAL

Calorific Value. Calculation of Calorific Value of Coal, DeCahier. Gas World, vol. 95, no. 2471, Dec. 12, 1931, pp. 596–599, 4 figs. Inaccurate results with calorimeters; objections to use of formulas based on ultimate analyses; calculation from proximate analysis; sulphur correction; new formula submitted. Bibliography.

Carbonization, Low-Temperature. Application of Low Temperature Coal Distillation to Modern Requirements, E. H. Smythe and E. G. Weeks. Colliery Guardian, vol. 143, no. 3699, Nov. 20, 1931, pp. 1705–1708, 5 figs. List of nine localities from which suitable coals are obtained; tests with Babcock process; description of simplified form of coal distillation plant designed primarily for continuous and automatic production of coal tar and graded semi-coke. Before Instn. Engrs and Shipbldrs. in Scotland.

Les procédés modernes d'utilisation rationnelle des combustibles (Modern Procedures in Economic Utilization of Fuels), H. L. deLeeuw. Technique Moderne, vol. 23, nos. 21 and 22, Nov. 1, 1931, pp. 709–713 and Nov. 15, pp. 747–754, 16 figs. Outline of latest development in processing of fuels, with special reference to low-temperature carbonization of coal, and utilization of its by-products.

Liquefaction. Light Spirits From Low Temperature Carbonization of Coal, D. Hicks and J. G. King. (Great Britain) Dept. Sci. and Indus. Research, Fuel Research—Tech. Paper, no. 34, 1931, 26 pp., 3 figs., 6 d.; see also Engineering, vol. 132, no. 3439, Dec. 11, 1931, pp. 737–738. Properties of spirits obtained by scrubbing gas and by distilling tar from low-temperature carbonization; methods of refining them; fuels obtained from tar by cracking or hydrogenation not considered.

COMPRESSED-AIR LINES

Fittings. Druckverlust in Formstuecken fuer Pressluftleitungen (Pressure Loss in Fittings for Compressed-Air Lines), E. Stach. Glueckauf, vol. 67, no. 45, Nov. 7, 1931, pp. 1400–1404, 11 figs. Tests with old and new forms of T-pieces and elbows, for determining best shape; tests were carried out with compressed air of 3 to 5 atm and for loads up to 9.5 cu m suction volume per min.

CONVEYORS

Pneumatic. Transporting Pulverized Coal by Pipe Line, F. Schulte. Pipe Line News, vol. 4, no. 1, Dec. 1931, pp. 11–13. German practice; suction operation preferable, but used only for distances up to 400 m; pressure used up to 800 m, but intermediate stations must be installed for greater distances; air consumption; explosion; moisture; fineness of dust; power consumption; wear; leaks; pipe laying; costs. Before Int. Conference on Bituminous Coal.

COPPER

Properties. Proprietes mecaniques du cuivre—1 (Mechanical Properties of Copper), A. Krupkowski. Revue de Metallurgie, vol. 28, no. 10, Oct. 1931, pp. 529–545, 16 figs. Results of investigations begun in 1928 at Warsaw Institute of Technology; tensile tests; effect of cold working of copper by drawing or rolling.

CRANES

Gantry. Enquête sur l'état actuel de la technique des Appareils de Levage et de Manutention mécanique (Investigation of Present State of Devices for Mechanical Lifting and Handling), M. Pelou. Science et Industrie, vol. 15, no. 214, Nov. 1931, pp. 508–518, 20 figs. Gantry cranes with traveling carriage hoists for handling of isolated loads and gantry cranes with grab-bucket traveling hoists.

CUPOLAS

Hot-Blast. Moore Hot-Blast Cupola, J. T. MacKenzie. Am. Foundrymen's Assn.—Trans. and Bul., vol. 2, no. 8, Aug. 1931, pp. 107–203 and (discussion) 203–204, 4 figs. Operating conditions demanding consideration of cupola melting other than by cold-blast cupolas led to development of method of suspending vertical pipes inside cupola; this installation was so satisfactory that other cupolas in this plant were changed over to hot-blast melting; operating records.

CUTTING TOOLS

Tungsten Carbide. Test for New Carbide Cutting Tools, A. W. Swanson. Machy. (N. Y.), vol. 38, no. 4, Dec. 1931, pp. 265–267, 3 figs. To determine applicability of tools, "cratering" test is made on lathe with approximately $^3/_{32}$-in. depth of cut, feed of 0.020 to 0.030 in., and moderate speed; formation of crater back of cutting edge of tool.

Cutting Steel With a New Cemented Carbide, R. D. Prosser. Machy. (N. Y.), vol. 38, no. 4, Dec. 1931, pp. 296–298, 4 figs. Efficiencies of Widia-X in tests on steel, and corresponding consumption of electrical current; efficiencies of tools tipped with Widia-X in machining various steels, compared with efficiency of Krupp's best high-speed steel.

Tungsten Carbide Tools. Engineer, vol. 152, no. 3960, Dec. 4, 1931, pp. 603–604, 4 figs. New machines by Alfred Herbert, Ltd.; tool is built up with Widia tip fixed in recess cut in mild-steel shank; results of tests carried out with Widia tools on 33-in. lathe.

Ueber das Loeten von Hartmetallen (Widia) [Soldering of Hard Metals (Widia)], C. Agte and K. Schroeter. Werkstattstechnik, vol. 25, no. 15, Aug. 1, 1931, pp. 373–374, 3 figs. Effects of different soldering methods on properties of tools to maintain cutting characteristics; benefits of reducing atmosphere.

DIE CASTINGS

Zinc. Zinc Die Castings, W. M. Peirce and M. Stern. Metal Progress, vol. 20, no. 6, Dec. 1931, pp. 53–58, 8 figs. Typical applications of aluminum-copper-magnesium alloys 4:3:0.1 per cent, with data on composition and strength properties; recommendations for machining and electroplating.

DIESEL-ELECTRIC POWER PLANTS

Stand-By. Diesel Stand-By Power in Hydro-Electric Plant, E. Swan. Power, vol. 74, no. 20, Nov. 17, 1931, pp. 708–709, 1 fig. Design and operating characteristics of Central Power Company's Diesel plant at Kearney, Neb.; necessity of breakdown power; list of equipment in Diesel power plants.

DIESEL ENGINES

Automotive. Der Entwicklungsstand der Schweroelmotoren fuer Fahrzeuge und Flugzeuge (Development of Heavy-Oil Engine for Motor Vehicles and Airplanes), W. Schwerdtfeger. Automobiltechnische Zeit., vol. 34, no. 30, Oct. 31, 1931, pp. 677–679, 1 fig. Comparison of representative designs of principal countries based on product of output per liter and mean effective pressure; rating of 2-cycle and 4-cycle engines.

Development. Diesel Engines, H. R. Ricardo. Engineering, vol. 132, nos. 3438–3440, Dec. 4, 11, and 18, 1931, pp. 704–706, 736–737, and 767, 13 figs. Dec. 4: It is stated that while Diesel failed in his primary object of making engine which could burn coal directly, engine turned out to be very good oil engine; at one time it was maintained that high-speed Diesel engines were impossible, but actually combustion is completed in Diesel in about two-thirds time taken in gasoline engine running at same speed. Dec. 11: During its first 30 years Diesel engine has changed little, merely increasing in size and little in speed; effect of supercharging; speeds of Diesel engines appear to have nearly reached their limit. Dec. 18: Analogy between development of Diesel engine and history of steam engine; author thinks high-speed Diesel will oust slow-running type; these engines would have piston speeds of over 1500 ft per min and cylinder diam. would be 8 in. at most. Three lectures before Roy. Soc. Arts.

Fuel Injection. Effectiveness of Double-Stem Injection Valve in Controlling Combustion in Compression-Ignition Engine, J. A. Spanogle and E. G. Whitney. Nat. Advisory Committee Aeronautics—Tech. Notes, no. 402, Dec. 1931, 19 pp., 19 figs. on supp. plates. Engine performance with double-stem valve inferior to that obtained with single-stem valve; control of injection rates permitted by injection valve of two stages of discharge not sufficient to effect desired rates of combustion.

Hydraulics of Fuel Injection Pumps for Compression-Ignition Engines, A. M. Rothrock. Nat. Advisory Committee Aeronautics—Report no. 396, 1931, 47 pp., 42 figs. Formulas for computing instantaneous pressures delivered by fuel pump; compressibility, elasticity, and inertia of fuel; resistance losses in injection tube; design of fuel pump injection systems; sample calculations.

Fuels. Ignition Quality of Fuels in Compression-Ignition Engines, G. D. Boerlage and J. J. Broeze. Engineering, vol. 132, nos. 3435, 3438, and 3440, Nov. 13, 1931, pp. 603–606; Dec. 4, pp. 687–689, and Dec. 18, pp. 755–756, 26 figs. Nov. 13: Results of laboratory research and tests on Thomassen direct-injection engine, using other engines mainly for correlation purposes. Dec. 4: Determination of ignition quality. Dec. 18: Correlation between engines.

High-Speed. Fowler Cavity Piston High-Speed Diesel Engine. Gas and Oil Power, vol. 26, no. 314, Nov. 5, 1931, pp. 332–334, 8 figs. Operating and design characteristics for which J. Fowler & Co. (Leeds), Ltd. claim enhanced smoothness of running and absence of "Diesel knock;" comparative fuel rate curves for gasoline and Fowler Diesel engines; performance curves for 2-cylinder Fowler Diesel engine.

Some Characteristics of High Speed Heavy-Oil Engines, S. J. Davies. Engineer, vol. 152, nos. 3962 and 3963, Dec. 18, 1931, pp. 656–657 and Dec. 25, pp. 681–682, 9 figs. Differences in characteristics of gasoline and heavy-oil engines; present trend of design; conditions of satisfactory performance; forms of combustion chamber. Before Instn. Mech. Engrs.

Marine. Die doppeltwirkenden Zweitakt-Dieselmotoren der Reichsmarine (Double-Acting Two-Cycle Diesel Engines of German Navy), W. Laudahn. V.D.I. Zeit., vol. 75, no. 47, Nov. 21, 1931, pp. 1425–1431, 17 figs. Design and performance characteristics of 9-cylinder engine for battleship "Deutschland," developing 7100 hp at 450 rpm; bore and stroke 420 by 580 mm; comparison with other engine installations of German navy.

Marine Oil Engine Trials. Engineering, vol. 132, nos. 3437, 3438, and 3439, Nov. 27, 1931, pp. 680–682 and (discussion) 676–678, Dec. 4, pp. 711–715 and Dec. 11, pp. 724–725, 11 figs. Sixth report of Marine Oil-Engine Trials Committee, giving results of tests on T.S.M.S. "Polyphemus" and her engines; covers trials ashore and at sea, and includes appendix on torsional oscillations occurring in crankshaft.

Trunk-Piston Diesel Engine, E. B. Pollister. Mar. Eng. and Shipg. Age, vol. 36, no. 12, Dec. 1931, pp. 564–569, 13 figs. New Busch-Sulzer engines incorporating innovations, overcome objectionable features of earlier types; possible to build trunk-piston Diesels in large cylinder sizes.

Pulverized-Fuel. Waermetheoretischer Vergleich des Kohlenstaubmotors mit einem normalen Dieselmotor (Thermodynamic Comparison of Pulverized-Coal With Standard Diesel Engine), A. Schor. Werft-Reederei-Hafen, vol. 12, no. 20, Oct. 15, 1931, pp. 349–352, 4 figs. Investigation of efficiency achieved in burning pulverized coal; temperatures of combustion; relative merits of combustion with constant pressure and with constant volume; theoretical entropy diagram for pulverized-lignite Diesel engine is developed.

Sulzer. Sulzer Brothers Build 10,800-Hp. Diesel, O. F. Allen. Power, vol. 74, no. 22, Dec. 1, 1931, pp. 786–788, 4 figs. European Diesel builder to construct large 2-cycle, double-acting Diesels; tests completed on 10,800 hp unit; design and features of specific installations; cross-section through working cylinder double-acting Sulzer engine; arrangement of starting servomotor of Sulzer Diesel engine; diagram of fuel-valve and injection-air-pressure control.

Supercharging. Leistungssteigerung bei Dieselmotoren durch "Aufladen" der Zylinder (Supercharging of Diesel Engines), Laudahn. Werft-Reederei-Hafen, vol. 12, no. 21, Nov. 1, 1931, pp. 365–366, 3 figs. Experiences and test results with various systems; supercharging is effective, reliable method of increasing power on given cylinder dimensions; advantages are only clearly shown for high supercharging, but nothing less than 25–30 per cent power increase is considered worth while.

Super-Atmospheric Oil Engine, H. Hunter. North-East Coast Instn. Engrs. and Shipbldrs.—Advance Paper, for mtg., Dec. 17, 1931, 23 pp., 16 figs. Type of engine dealt with is that usually known as supercharged engine; engines constructed on Buechi system; work carried out in Europe; this type of engine can develop 50 per cent more power than normal engine with no greater heat stresses; service performance of ships driven by super-atmospheric engines.

Vibration. Isolating Diesel Engines Against Vibration, T. E. Wilson, Jr. Diesel Power, vol. 9, no. 11, Nov. 1931, pp. 557–559, 4 figs. Review of general causes of machinery vibration with special regard to Diesel engine installations; suggestions as to remedies and means available for correction.

ELECTRIC FURNACES

Annealing. Continuous Strip Annealing Process and Fundamentals of Heat Transfer in Continuous Strip Furnaces, O. Junker. Metals and Alloys, vol. 2, no. 6, Dec. 1931, pp. 352–354, 7 figs. Process which considerably reduces labor cost by combining pickling, washing and drying operations. Translated from Zeit. fuer Metallkunde, Apr. and May 1931.

Wirtschaftlichkeit und thermischer Wirkungsgrad neuzeitlicher Elektrooefen zum Gluehen von Metallen (Economy and Heat Efficiency of Modern Electric Annealing Furnaces), H. Masukowitz. Zeit. fuer Metallkunde, vol. 23, no. 12, Dec. 1931, pp. 335–337, 9 figs. Furnaces for annealing brass tubes and rods are compared and great influence of deadweight discussed; new Junker-Osnabrueck furnace, also muffle furnace with thin heating plates enclosing heating spirals, are described.

Heat-Treating. Recent Developments in Electric Heat Treating Equipment, H. M. Webber. Fuels and Furnaces, vol. 9, no. 12, Dec. 1931, pp. 1393–1398, 7 figs. Development of electric furnaces for bright annealing cold steel strip and non-ferrous metals, for sheet annealing, copper brazing, air-draw furnace, box-type furnace, and apparatus for producing gases for use as controlled atmospheres.

Melting. Melting of Gray and Malleable Iron in Indirect-Arc Furnace, J. C. Bennett and J. H. Vogel. Am. Foundrymen's Assn.—Trans. and Bul., vol. 2, no. 8, Aug. 1931, pp. 235–253 and (discussion) 254–256, 12 figs. Operation of electric furnace; temperatures are checked by optical pyrometer; fracture test bars are used to check iron; data of iron qualities; costs of operation.

ELECTRIC RELAYS

Photoelectric. Photoelectric Relays, L. H. Matthias. Radio Eng., vol. 11, no. 12, Dec. 1931, p. 17, 2 figs. Photoelectric relay used as counting relays, limit switches, alignment controls, sorting devices, automatic smoke detectors, for signs, airplane beacons and warning lights, offices, etc.; notes on operation, relay, power supply and installation.

ELECTRIC WELDING

Arc—Time Study. Die Arbeitszeitermittlung Beim Lichtbogenschweissen (Time Study in Electric Arc Welding), M. Zscheile. Werkstattstechnik, vol. 25, no. 17, Sept. 1, 1931, pp. 414–416, 4 figs. Determination of time requirements based on volume of fillet welds; interpretation of test data for different electrodes and dimensions of seams.

Resistance - Machines for. Elektrische Widerstand-Abschmelz-Schweissmaschine mit Pressluftеinspannung (Electric Resistance Welding Machine With Pneumatic Clamping), B. Langbein. Werkzeugmaschine, vol. 35, nos. 17 and 19, Sept. 15, 1931, p. 347 and Oct. 15, pp. 388–390, 5 figs. Design and operating characteristics of type built by AEG.

FLOW OF FLUIDS

Pipes. Ueber Duesenwirkungen mit gleichbleibendem und veraenderlichem Anfangsdrucke (Nozzle Effects With Constant and Variable Initial Pressure), H. Backhaus. Zeit. des Oesterreichischen Ingenieur und Architekten Vereines, vol. 83, no. 23–24, June 12, 1931, pp. 195–197, 8 figs. Effects of small changes in cross-sections of pipe lines on coefficient of state, with particular regard to steam.

FUELS

Calorific Value. Thermodynamics of Difference Between Gross and Net Heating Values, Solid and Liquid Fuels, L. C. Lichty and B. L. Brown. Indus. and Eng. Chem., vol. 23, no. 12, Dec. 1931, pp. 1419–1421, 3 figs. Temperature-volume or -pressure diagrams are shown representing burning and cooling processes, which illustrate reason for and fix definition of difference between gross and net values. Before Am. Chem. Soc.

FURNACES, MELTING

Pulverized-Coal. Manufacture of High-Grade Castings in Brackelsberg Rotary Furnace, P. M. Macnair. Foundry Trade Jl., vol. 45, no. 800, Dec. 17, 1931, pp. 379–381. Modern ideas on how improvements can best be obtained in properties of cast iron, and extent to which this is accomplished in rotary pulverized-fuel-fired furnaces; advantages of furnace for production of high-grade castings. Before Inst. Brit. Foundrymen.

FURNACES, METALLURGICAL

Temperature Measurement. Ueber Temperaturmessung und -regelung in metallurgischen Oefen (Temperature Measurement and Regulation in Metallurgical Furnaces), F. Kofler and G. Schefels. Stahl und Eisen, vol. 51, no. 50, Dec. 10, 1931, pp. 1529–1535, 13 figs. Continuous temperature measurements in heating furnaces, regenerators, in rolling mills and on mixers; temperature-control apparatus; tests with control apparatus for strip-steel annealing furnaces and ingot-heating furnace.

GAS ENGINES

Steel-Mill. Developments in Gas Engines for Steel Mills. Rolling Mill Jl., vol. 5, no. 10, Oct. 1931, pp. 677–678. How steel mill with supply of blast-furnace gas and demand for power, shaped modern gas engine; question of gas engine vs. steam turbine may be solved as follows: where gas is scarce, and fuels expensive, or economy with water is necessary, gas engines hold advantage. Previously indexed from Stahl und Eisen, Sept. 17, 1931.

GAS TURBINES

Bertin. Nouveau principe du travail des gaz et de la vapeur dans les turbines (New Principle of Action of Gas and Steam in Turbines), G. Bertin. Chaleur et Industrie, vol. 12, no. 139, Nov. 1931, pp. 593–597, 13 figs. Theoretical treatise on principles of Bertin turbine.

GEARS

Geneva Stop. Inverse Geneva Wheel Motion, W. P. Willett. Machy. (N. Y.), vol. 38, no. 4, Dec. 1931, pp. 260–261, 3 figs. Design and operating principles of Geneva mechanism for producing intermittent circular motion, in which driving and driven members rotate in same direction.

Variable-Speed. Friction-Driven Infinitely-Variable Speed Gear. Engineering, vol. 3437, Nov. 27, 1931, pp. 669–670, 5 figs. Gear, with self-adjusting friction transmission, being manufactured by W. H. Dorman and Co.; apparatus is made in four types.

Worm. Worm Gearing and Some of Its Applications, B. J. Shillito. Engineer, vol. 152, no. 3961, Dec. 11, 1931, pp. 615–617, 1 fig. Application to various types of machinery, including dynamos, electrically driven grinding mills, printing-press equipments and rolling and rubber mills, based on experience in manufacture and design of these drives during last 25 years.

GLUCINUM ALLOYS

Properties. Le glucinium et la construction aeronautique (Glucinium and Aeronautical Construction), L. Guillet and M. Ballay. Revue de Metallurgie, vol. 28, no. 10, Oct. 1931, pp. 525–528. Pure glucinium and ultra-light alloys; light alloys of aluminum-glucinium; properties of heavy glucinium alloys consisting of additions of small quantities of glucinium to nickel, copper,a nd to iron; price of glucinium is dominant factor governing its industrial use at present time.

HARDNESS TESTING

Vickers Machine. Vickers Pyramid Diamond Hardness Testing Machine, G. R. Barclay. Metal Industry (Lond.), vol. 30, no. 16, Oct. 16, 1931, pp. 371–373, 7 figs. Limitations of Brinell test; construction and operation of Vickers machine; relation between Vickers and Brinell figures.

HEAT EXCHANGERS

Calculations for. Berechnung von Waermeaustausch- insbesondere Gegenstromapparaten (Calculation of Heat Exchangers With Particular Regard to Counterflow), F. Filchner. Gesundheits-Ingenieur, vol. 54, no. 35, Aug. 29, 1931, pp. 521–525, 13 figs. Development of graphical methods with numerical examples illustrating calculation for steam and water heat exchangers and preheaters.

Naeherungsverfahren zur Berechnung des Waermeaustausches in Regeneratoren (Approximated Method for Calculating Heat Exchange in Regenerators), H. Hausen. Zeit. fuer angewandte Mathematik und Mechanik, vol. 11, no. 2, Apr. 1931, pp. 105–114, 11 figs. Theoretical development of graphic and analytical methods of approximation for determining temperature of different types; formulas for calculating efficiency.

HEAT PUMPS

Design. Il riscaldamento meccanico con ciclo a vapor d'acqua e con cicli bineri (Mechanical Heating by Means of Steam Cycle and Binary Cycle), L. d'Amelio. Elettrotecnica, vol. 18, no. 7, Mar. 5, 1931, pp. 141–150, 14 figs. Various methods of converting mechanical work into heat with particular regard to thermodynamic aspects; layout of heat exchange apparatus.

HEAT TRANSMISSION

Cylinders. Ueber den Temperaturverlauf in einem Zylinder von endlicher Laenge beim Abkuehlen und Erwaermen (Temperature Distribution in Cylinders of Finite Length During Cooling and Heating), F. Berger. Zeit. fuer Angewandte Mathematik und Mechanik, vol. 11, no. 1, Feb. 1931, pp. 45–58, 9 figs. Theoretical calculation for determining temperature of certain points at given time or to find temperature changes of certain points as function of time; numerical examples.

Measurements. Procédé de mesure des coefficients de conductibilite calorifique (Method of Measurement of Heat Conductivity Coefficients), Heyberger. Société Française des Électriciens—Bul., vol. 1, no. 11, Nov. 1931, pp. 1226–1234, 7 figs. Heat transmission through walls; methods used as Conservatoire des Arts et Métiers; coefficient for solid cylinder; experimental verifications.

HELICOPTERS

Stability. La stabilità degli elicotteri (Stability of Helicopters), U. deCaria. Aeronautica, vol. 5, no. 7, July 1931, pp. 471–476, 6 figs. Relative merits of different methods of control with particular regard to means of balancing of reaction forces of lifting screw.

HONING MACHINES

Hydraulic - Drive. Hydraulically - Operated Cylinder-Honing Machine. Engineering, vol. 132, no. 3440, Dec. 18, 1931, p. 760, 5 figs. partly on p. 761. Machine constructed by Mayer and Schmidt, A.G.; there is no separate work table, this being formed by base to which main column is bolted.

HYDRAULIC LABORATORIES

United States. Work Starts on National Hydraulic Laboratory in Washington, B. R. Van Leer. Eng. News-Rec., vol. 107, no. 26, Dec. 24, 1931, pp. 996–998, 2 figs. Planning and campaigning for National Hydraulic Laboratories; contract for construction of laboratory let at $294,887; main experimental flume will be 12 ft wide, 12 ft deep and approximately 234 ft long; comparison with other hydraulic laboratories; purposes and major features of laboratory.

HYDRAULIC TURBINES

Types and Applications. L'aménagement des chutes d'eau et les turbines hydrauliques (Utilization of Water Falls and Hydraulic Turbines), A. Ténot. Chaleur et Industrie, vol. 12, nos. 137 and 139, Sept. and Nov. 1931, pp. 483–490 and 603–612, 19 figs. Sept. 1: Survey of present-day water-wheel and hydraulic-turbine practice; tendencies in their design and construction; classification of water wheels and turbines; Kaplan turbines; conical diffusers. Nov.: Various types of runners illustrated and described; runner mounting; efficiency curves.

HYDROELECTRIC POWER DEVELOPMENTS

Quebec. Beauharnois Harnesses St. Lawrence for 2,000,000 Hp. Elec. World, vol. 98, no. 20, Nov. 14, 1931, pp. 860–865, 10 figs. Provision also made for deep waterway; electrically driven machinery used for excavation; four 50,000-hp. units constitute initial installation; six more to be added during next three years; detailed illustration of operating gallery between wheel and generator levels.

HYDROELECTRIC POWER PLANTS

Efficiency. Sur le rendement des centrales hydroelectriques (Efficiency of Hydroelectric Power Plants), Loubry. Société Française des Electriciens—Bul., vol. 1, no. 11, Nov. 1931, pp. 1198–1201, 1 fig. Efficiency plays more important part in hydroelectric power plants than in steam plants, as output is also limited by available water; short mathematical analysis.

Manitoba. Winnipeg Hydro-Electric System's Slave Falls Development. Elec. News and Eng., vol. 40, no. 23, Dec. 1, 1931, pp. 27–31, 9 figs. Development located 80 miles northeast of Winnipeg, put into commercial operation on Sept. 1st; at present, two of ultimate eight 12,000-hp units are in operation although it is expected that plant will reach its full capacity on or before peak load period of year 1935.

Pumped-Storage. Ackumulering av hydraulisk energi (Accumulation of Hydraulic Energy), K. A. Ahlfors. Tekniska Foereningens i Finland Foerhandlingar, vol. 51, no. 8, Aug. 1931, pp. 235–246, 23 figs. Methods of providing power reserve for peak-load requirements; representative German installations, with particular regard to pumping equipment.

INDUSTRIAL MANAGEMENT

Budget Control. Building Budgets for Incentives and Standard Costs, R. E. Case. Factory and Indus. Mgmt., vol. 82, no. 5, Nov. 1931, pp. 650–652, 1 fig. Method of combining budget to serve as basis for standard costs and bonus systems, which does not work out in practice; methods of efficient budget control; construction of standard cost line.

Cost Accounting. Cost Control. Power, vol. 74, no. 21, Nov. 24, 1931, pp. 731–776, numerous figs. Fundamental approach to power costs; master chart of power services; accounting based on master chart; master chart examples; plant accounting; hydro, Diesel, engine or turbine, turbine unit, boiler, water pumping, water heating, air compressing, compressor refrigeration, absorption refrigeration, and air conditioning plant costs; power-cost control applied to industrial plant.

Inventory Control. Simplicity and Accuracy Are Features of This Inventory System, J. J. Berliner. Modern Machine Shop, vol. 4, no. 6, Nov. 1931, pp. 20–22, 24, 26, 28, 70, and 72–73, 4 figs. Inventory-taking at plant of Pressed and Welded Steel Products Co.

Job Analysis. What Is Skill Worth? H. H. Tullis. Factory and Indus. Mgmt., vol. 82, no. 5, Nov. 1931, pp. 623–625, 4 figs. Outline of job classification employed by American Rolling Mill Co., Middletown, Ohio; principles set up as guide in ranking jobs on skill and pay basis; selected jobs showing effect of classification plan on present job earnings.

Motion Study. Manufacturing Costs Reduced by Application of Motion Study, N. Bournes. Mech. World, vol. 90, no. 2341, Nov. 13, 1931, pp. 478–481, 2 figs. Analysis of how reductions were made by investigating operator's movements when engaged on particular type of work.

Measurement. Der absolute Beschaeftigungsgrad (Absolute Factor of Occupation), C. Klotzsch and R. Kuebler. Technik und Wirtschaft, vol. 24, no. 10, Oct. 1931, pp. 241–244, 2 figs. Factor is defined according to Verein Deutscher Maschinen Anstalten, as relation between number of workers multiplied by scheduled working time to effective man-hours; application in cost calculation and introduction of absolute factor of occupation and its advantages.

Office Management. Das neuzeitliche Buero (The Modern Office), G. Brandi. Technik und Wirtschaft, vol. 24, no. 9, Sept. 1931, pp. 213–217, 2 figs. Success in modern office organization depends on three elementary factors, i.e., planning of work, employees and working equipment and their adequate application in operating.

Organization. Konstruktion und Fertigung in Wechselwirkung (Relation Between Design and Production), E. A. Kraft. Machinenbau, vol. 10, no. 17, Sept. 3, 1931, pp. 559–562, 3 figs. Policies of promoting team work between engineers in production and design; benefits derived from combination of theory and practice illustrated by examples; wider application of standards.

Production Control. Fitting Working Schedule to Decreased Demand—I and II. Factory and Indus. Mgmt., vol. 82, nos. 4 and 5, Oct. 1931, pp. 512–514 and Nov., pp. 655–656. Practical review of proper methods of planning production schedules and profits when business is slack; outline of system employed in German factory; labor computations; company analysis of effects on costs and profits.

Hilfsmittel fuer die Kontrolle der laufenden Betriebs-Unkosten (Means for Control of Current Operating Costs), W. Mueller-Paersch. Maschinenkonstrukteur, vol. 64, no. 19–20, Oct. 10, 1931 (Supp.), pp. 209–210, 3 figs. Graphical representation of principal factors entering into cost of production, particularly of overhead.

Output Regularized Despite Fluctuating Demands, G. E. Schloot. Iron Age, vol. 128, no. 20, Nov. 12, 1931, pp. 1223–1227 and 1281, 7 figs. To avoid necessity of fluctuations in plant activity to meet uneven outflow of products, Diamond Chain & Mfg. Co., Indianapolis, devised production-control system that aims to regularize output; plan enabled company to reduce production costs, improve quality of products and insure prompt deliveries.

Production Control in Drop Forge Plants, L. E. Ruby. Heat Treating and Forging, vol. 17, no. 11, Nov. 1931, pp. 1029–1033, 7 figs. Organization of production control at plant of Pittsburgh Forgings Co., Jackson, Mich.; blanks for production estimate, shop order, work ticket, machine schedule, etc.

Unified Production Methods—I and II, J. J. Phalen. Factory and Indus. Mgmt., vol. 82, nos. 4 and 5, Oct. 1931, pp. 485–487, and Nov., pp. 642–646, 6 figs. Unified code of standards for simplified superintendence of production, enveloping control of raw material, finished product, inventories and budgeting, now in operation at Mergenthaler Linotype Co., Brooklyn, N. Y.; records and operating features of production schedule.

Time Study. Die Beruecksichtigung der Arbeitsintensitaet in der Arbeitsmessung (Continuation of Working Intensities in Measurement of Work), E. Kupke. Werkstattstechnik, vol. 25, no. 14, July 15, 1931, pp. 345–348. Development of general formula for work and establishment of relations between work measurement and compensation; measurement of working intensities according to Refa and Bedaux.

Psychology and Salesmanship in Applying Time Study, R. W. Gray. Am. Mach., vol. 75, no. 26, Dec. 24, 1931, pp. 964–966, 1 fig. Interpretation of experiences relating to incentive and operation analysis in different departments of Westinghouse Electric and Manufacturing Co.

INTERNAL-COMBUSTION ENGINES

Coal-Dust. See *Diesel Engines* (Pulverized-Fuel).

Cooling. Untersuchungen ueber den Einfluss stein- und rostfreier Kuehlwasserraeume auf Leistung und Brennstoffverbrauch bei Explosionsmotoren (Investigation of Scale and Corrosion-Proof Cooling-Water Chambers on Efficiency and Fuel Consumption of Explosion Engines), H. Balcke. Waerme, vol. 54, nos. 51–52, Dec. 19, 1931, pp. 948–951, 3 figs. Results of tests on 4-cylinder Buessing engine; advantages of engines with treated cooling water.

Cylinder Heads. Einwandfreie Zylinderkopf-Abdichtung (Satisfactory Cylinder Head Gaskets), O. Wieszner. Deutsche Motor-Zeit., vol. 8, nos. 8 and 10, Aug. 1931, pp. 284–285 and Oct., pp. 360, 362, 364, and 366, 7 figs. Requirements of gaskets for reliable performance; advantages of "Renz-Spezial" gaskets with tolerance 0.03 mm, made in thicknesses of 0.6–0.8 and 1.2–1.5 mm; asbestos and wire-mesh combination.

[See also *Airplane Engines; Diesel Engines; Gas Engines; Oil Engines.*]

IRON-FOUNDRY PRACTICE

Electric Melting. Electric Process for Iron for Cylinder and Cylinder-Head Castings, H. E. Bromer. Am. Foundrymen's Assn.—Trans. and Bul., vol. 11, no. 12, Dec. 1931, pp. 585–601, 5 figs. In order to produce consistently better grade of iron than was possible by cupola melting alone, electric furnace was installed; experimental work was carried on while using both types of melting furnaces; later, duplex process was used; details of various practices.

LATHES

Manufacture. Fliessende Fertigung im Drehbankbau (Continuous Production in Manufacture of Lathes), W. V. Schuetz. Werkstattstechnik, vol. 25, no. 16, Aug. 15, 1931, pp. 389–396, 13 figs. Economies represented by plant layout and production methods of company forming Vereinigten Drehbankfabriken-A.G.; examples illustrate application of diamond and interchangeability of parts.

Selection. Auswahl von Drehbaenken (Selection of Lathes), P. Uhlich. Werkstattstechnik, vol. 25, no. 14, July 15, 1931, pp. 350–352, 7 figs. Requirements of lathes for different types of work including internal-combustion engines, electric motors, shafts and shafting, small parts of screw stock, etc.

LOCOMOTIVES

Articulated. Western Pacific Operating 2–8–8–2 Types in Fast-Freight Service. Ry. Age, vol. 91, no. 26, Dec. 26, 1931, pp. 975–976, 2 figs. Six locomotives recently purchased from Baldwin used on western division to replace 2–6–6–2, 2–8–2, and 2–8–0 type locomotives; design and operating features; principal weights and dimensions of Western Pacific simple articulated 2–8–8–2 type locomotives compared with those of locomotives displaced.

Boilers. Einwirkung des Kesselsteins auf den Wirkungsgrad des Lokomotivkessels (Effects of Boiler Deposits on Efficiency of Locomotive Boilers), F. Boehm. Organ fuer die Fortschritte des Eisenbahnwesens, vol. 86, no. 14, July 15, 1931, pp. 299–303, 7 figs. Experimental investigation of effects of deposits in various parts of boiler on fuel consumption and cost of operation by German state railroads.

Compound. Compound Locomotives: Their Practical Economy and Disadvantages, E. L. Diamond. Ry. Engr., vol. 52, no. 622, Nov. 1931, pp. 430–432, 8 figs. Review of factors which influence performance of compound engine; design and operating characteristics at various speeds.

Diesel. Diesel Locomotive Solves Railroad Problems, O. F. Allen. Power, vol. 74, no. 26, Dec. 29, 1931, pp. 928–931, 7 figs. Oil-engine locomotives, while still few in number proved their efficiency and adaptability in varied fields of application, from switching service to high-speed main-line passenger service; review of design and operating developments, together with specific examples.

High Power Slow Speed Diesel Electric Switching Locomotive. Diesel Power, vol. 9, no. 10, Oct. 1931, pp. 499–501, 5 figs. Design, construction and operating features of Diesel-electric locomotives manufactured by Heisler Locomotive Co., Erie, Pa.; speed sacrificed to starting torque; data derived from dynamometer and road tests.

Small Diesel Locomotives. Ry. Gaz., vol. 55 no. 22, Nov. 27, 1931, pp. 684–686, 5 figs. New types developed by Motor Rail Ltd., of Simplex Works, Bedford, for use on railways and by industrial concerns; design and operating characteristics of Simplex Diesel locomotives for 2 ft gage and standard gage.

Direct-Steaming. Direct Steaming Effects Fuel Economy and Increases Locomotive Availability, L. C. Winship. Combustion, vol. 3, no. 5, Nov. 1931, pp. 17–19, and 27, 4 figs. Design and operating characteristics of direct steaming installation at new Boston Terminal of Boston and Maine Railroad; outline of main operating advantages.

Electric. Descrizione delle locomotive trifasi gruppo E 554 ed E 432 (Description of Three-Phase Locomotives Types E 554 and E 432), G. Bianchi and S. Elena. Revista Tecnica delle Ferrovie Italiane, vol. 39, no. 6, June 15, 1931, pp. 257–293 and vol. 40, no. 1–2, July 15-Aug. 15, pp. 11–40, 89 figs. partly on supp. plates. Complete details and drawings of locomotives for 3000 volts, 15 cycle, total output 1500 kw, at speed of 25 and 50 km per hr, respectively, tractive effort 10,500 and 14,000 kg.

Feedwater Heaters. Scale Prevention in Closed Feedwater Heaters, J. Alsberg. Ry. Mech. Engr., vol. 105, no. 11, Nov. 1931, pp. 537–538. Results of research begun by Superheater Co., in 1922 to eliminate scale in closed feedwater heaters; use of anti-foaming compounds; tannin-brick treatment.

Gasoline-Electric. New Gas-Electric Locomotive Placed in Service. Motive Power, vol. 2, no. 11, Nov. 1931, p. 15, 3 figs. Design and operation of 50-ton gas-electric locomotive for use in local passenger service constructed by Vulcan Iron Works, Wilkes-Barre, Pa.; locomotive powered by two 175-hp, 6-cylinder LeRoi gasoline engines, each direct connected to 500-volt generator.

Testing. Santa Fe Locomotive 5000 Shows High Sustained Power. Ry. Mech. Engr., vol. 105, no. 12, Dec. 1931, pp. 569–572, 13 figs. Develops drawbar pull of 82–500 lb at 15 mph and 50,000 lb at 33 mph, equivalent to 4350 drawbar-hp; general characteristics and dimensions of Santa Fe locomotive 5000; tabular review of general performance; condensed profile of Atchison, Topeka and Santa Fe, Pecos Division, between Clovis, N. M., and Belen.

Valve Gears. Die Entwicklung der Ventilsteuerungen bei den Oesterreichischen Bundesbahnen (Development of Valve Gears of Austrian Federal Railroads), A. Lehner. Organ fuer die Fortschritte des Eisenbahnwesens, vol. 86, no. 5, Mar. 1, 1931, pp. 129–138, 10 figs. Design and operating characteristics of principal valve gears with particular regard to Lentz and Caprotti types.

LUBRICANTS

Requirements. Anforderungen an Schmiermittel (Requirements of Lubricants), C. Walther. Maschinenbau, vol. 10, no. 21, Nov. 5, 1931, pp. 670–675, 8 figs. Selection of lubricating oil; viscosity and dependence on temperature; semiliquid friction and "oiliness," changes in lubricants through long use. Bibliography.

LUBRICATION

Film Adherence. Recherches expérimentales sue l'adhérence aux métaux des couches lubrifiantes (Experimental Investigation of Adhesion of Lubricating Films to Metals), A. Boutaric and R. Amiot. Académie des Sciences—Comptes Rendus, vol. 193, no. 15, Oct. 12, 1931, pp. 593–594. Investigation of importance of thickness of lubricating film and of metallic support.

MACHINE TOOLS

Castings. Die Eigenschaften des Gusseisens guter Gleitbahnen von Werkzeugmaschinenbetten, etc. (Properties of Cast Iron for Slides of Machine-Tool Beds and Methods of Manufacture), R. Marker. Giesserei, vol. 18, no. 47–48, Nov. 27, 1931, pp. 901–905, 1 fig. Properties required of machine-tool slides; structure with pearlitic ground mass, thin-layer eutectic graphite and only slight phosphide content recommended as characteristics which cast iron for machine-tool beds should possess.

Cutting Pressure. Neues Verfahren zur Messung schnellwechselnder mechanischer Kraefte (New Method of Measuring Rapidly Changing Mechanical Forces), A. Wallischs and H. Opitz. Stahl und Eisen, vol. 51, no. 48, Nov. 26, 1931, pp. 1478–1479, 5 figs. Patented method developed in laboratory of Aachen Institute of Technology for inertia-free measurement of faces by electrical means, especially cutting forces in machine tools.

Nitrided Steel. Neuere Erfahrungen mit Nitrierstahl, insbesondere im Werkzeugmaschinenbau (Recent Experiences With Nitrided Steel, Especially in Machine-Tool Construction), W. Haufe and F. Bruehl. Kruppsche Monatshefte, vol. 12, Nov. 1931, pp. 295–299, 9 figs. Advantages of nitrided steel; behavior of nitrided gear wheels as drive for heavy machine tools; after 10,000 working hours not slightest deterioration was apparent; results of tests on spindles, crankshafts, etc.

Diversified Replacement in Small Plant, D. S. Linton. Am. Mach., vol. 75, no. 26, Dec. 24, 1931, pp. 946–952, 18 figs. Machining costs were cut 18.6 per cent in 2½ years, assembly costs 38 per cent in half that time and quality was improved as result of thoroughgoing replacement policy adopted by Rotor Air Tool Co.

Profitable Replacement in "Average Lot" Plant, H. P. Bailey. Am. Mach., vol. 75, no. 23, Dec. 3, 1931, pp. 836–853, 19 figs. Equipment replacement policy of Warner and Swasey shop; effect of variations in saving of production time, with same per cent of activity and with same investment; effect of varying percentages of activity on time to repay; effect of business conditions on replacement policy.

Replacing Equipment to Decrease Sales Resistance, G. S. Tracy. Am. Mach., vol. 75, no. 20, Nov. 12, 1931, pp. 743–753, 17 figs. Replacing policy of Geometric Tool Company, New Haven, Conn.; production capacity doubled with floor-space reduction by 60 per cent.

MACHINERY

Vibrations. Elimination of Vibration, R. B. Grey. Mech. World, vol. 90, no. 2342, Nov. 20, 1931, pp. 505–508, 4 figs. Outline of principles and methods author has used to prevent transmission of vibration and noise from machinery in general and Diesel engines in particular.

Svingninger I Maskindele (Vibrations in Machine Parts), A. R. Holm. Ingenioeren, vol. 40, no. 28, July 11, 1931, pp. 338–346, 19 figs. Theoretical aspects of principal types of vibrations; harmonic analysis of vibrations in internal combustion engines; methods of damping.

MATERIALS HANDLING

Germany. Mechanical Handling in Germany, T. Rich. Mech. Handling, vol. 18, no. 11, Nov. 1931, pp. 363–364, 4 figs. Remarkable progress has taken place in Germany in last 20 years regarding mechanical handling, not merely where materials in large bulk are concerned, but also where moderate quantities are in question; review of developments in equipment and methods employed.

Railroad Repair Shops. Trucks and Tractors Show Economies in Material Handling. Ry. Elec. Engr., vol. 22, no. 12, Dec. 1931, pp. 317–319 and 334, 14 figs. Chesapeake and Ohio develops system of shop transportation using both electric and gasoline equipment at Russell, Ky. and Huntington, W. Va.; color-light signals employed in transportation systems.

METALS

Cold Rolling. Cold Rolling Machines. Machy. (Lond.), vol. 39, no. 999, Dec. 3, 1931, pp. 297–299, 7 figs. Operating principles of design by Williams Manufacturing Co.; use of epicyclic rollers; advantages from point of view of rapid and accurate production and waste elimination.

Creep. Photographic Creep Testing Apparatus, D. A. Roberts and R. L. Dowdell. Metals and Alloys, vol. 2, no. 6, Dec. 1931, pp. 349–351, 5 figs. Combination of furnace and camera constructed at University of Minnesota; apparatus for determination of flow of metals at elevated temperatures.

Deformation. Ueber bildsame Formgebung in Rechnung und Versuch (Plastic Deformation in Calculations and Tests), E. Siebel. Stahl und Eisen, vol. 51, no. 48, Nov. 26, 1931, pp. 1462–1468, 13 figs. Review of research on behavior of metals; comparison of elastic and plastic deformation; investigations of creep of metals; rolling pressure and efficiency; stress conditions with slight permanent deformations; losses due to metal working, such as drawing, forging, and rolling.

Extrusion. Extrusion of Metals—V and VI, C. A. Colombel. Rolling Mill Jl., vol. 5, nos. 11 and 12, Oct. 1931, pp. 667–670 and Nov., pp. 719–722, 6 figs. Oct.: Extrusion of hollow sections, particularly extrusion of round tubing. Nov.: Principles and practice employed in extrusion and drawing of non-ferrous tubing.

Light. Einfluss der Probestabform auf Zugfestigkeit und Bruchdehnung von duennen Leichtmetallblechen (Effect of Shape of Test Piece on Tensile Strength and Elongation of Thin Sheets of Light Metals), K. Schraivogel. Jahrbuch 1931 der Deutschen Versuchsanstalt fuer Luftfahrt—Jahrestericht der Stoff-Abteilung, pp. 485–494, 18 figs. Author concludes that test piece of same shape may be used for various thicknesses of sheet, comparable results being obtained with duralumin, lautal, elektron.

Machinability. Machinability of Metals, A. H. d'Arcambal. Can. Chem. and Met., vol. 15, no. 10, Oct. 1931, pp. 270–272. Author recommends high-manganese steels, sulphonated cutting oils, and chromium-plated tools; field is seen for tantalum carbide-tungsten carbide tool material. Before Am. Soc. Steel Testing.

Machining. Forschung und Praxis auf dem Gebiete der spanabhebenden Formung (Research and Practical Experience in Chips Producing Shaping), M. Kronenberg. Sparwirtschaft, vol. 9, no. 9, Sept. 1931, pp. 355–363, 8 figs. New viewpoints on progress in cutting speed, cutting pressure, required power and chipping tables for turning; practical design examples.

MILLING CUTTERS

Power Requirements. Rechnungsgrundlagen zur Ermittlung des Leistungsbedaries bei Walzenfraesern (Calculating Data for Determining Power Requirements for Cylindrical Milling Cutters), G. Schlesinger. Werkstattstechnik, vol. 25, no. 17, Sept. 1, 1931, pp. 409–413, 8 figs. Further development of calculation by O. Salomon, which includes specific cutting pressure, chip dimension, speed, feed, and diameter; data on milling of electron, brass, steel, and cast iron.

OIL ENGINES

High-Speed. Tangye High-Speed Heavy-Oil Engine. Gas and Oil Power, vol. 26, no. 314, Nov. 5, 1931, pp. 325–326, 2 figs. Design and constructional features of single-cylinder, high-speed, cold-starting, vertical, heavy-oil engine, designed to give 8–10 bhp at 1000–1200 rpm.

PHOTOELECTRIC CELLS

Industrial Applications. Photo - Tubes Have Wide Field in Plant Operations, B. S. Havens. Automotive Industries, vol. 65, no. 24, Dec. 12, 1931, pp. 902–904, 4 figs. Intermittent and line-welding machine equipped with Thyratron control; automatic indication of passage of refrigerator unit through production; wire-drawing machine equipped with Thyratron control of rereeling tension; automatic switching mechanism on system of conveyors.

PIPE JOINTS

Welded. Design of Special Pipe Joints, S. Hirschberg. Welding Engr., vol. 16, no. 12, Dec. 1931, pp. 27–31, 14 figs. Engineering phases of welded piping installations as reflected by recent developments in pipe fittings for welded construction; expansion bends and relative flexibility of elbows; welded headers and shop fabrication. Before Int. Acetylene Assn.

PRESSES

Hydraulic. Hydraulic Presses in Steel Industry, E. Pfann. Eng. Progress, vol. 12, no. 7, July 1931, pp. 155–157, 4 figs. Design and operating characteristics of following: forging presses; plate forming and flanging presses riveting machines; frame; perforating, drawing and upsetting presses.

Toggle. Humphris Press. Engineer, vol. 152, no. 3961, Dec. 11, 1931, pp. 632–633, 4 figs. System of press-tool work devised by F. Humphris, and manufactured by Mass Products, Ltd.; idea is to provide toggle press which is so uniform in its pressing that full-sized sheet of metal as ordinarily rolled can be operated upon for production of multiplicity of small articles at one stroke across its whole width.

PRESSURE VESSELS

Design. Berechnung der Aussteifungspringe von Fachwerken (Design of Stiffening Rings for Framed Structures), P. Michnik. Bauingenieur, vol. 12, no. 44, Oct. 30, 1931, pp. 787–789, 4 figs. Theoretical mathematical discussion leading to derivation of formulas for design of stiffeners for framed pressure vessels, such as gas holders, cooling towers, etc.

PRINTING MACHINERY

Vibrations. Reducing Effects of Vibration by Means of Isolating Devices, M. F. Baldwin. Inland Printer, vol. 88, no. 3, Dec. 1931, pp. 45–48, 6 figs. Comments of printers and press manufacturers concerning harmful effects of excessive machinery vibration and noise and methods of reducing them; outstanding characteristics of standard vibration-absorbing materials available for printing-plant use.

PULVERIZED COAL

See *Conveyors.*

PUMPS

Centrifugal. Selection and Operation of Centrifugal Pumps, M. Phillips. Power, vol. 74, no. 24, Dec. 15, 1931, pp. 861–863, 3 figs. Instructions for proper selection, installation, and maintenance.

RAIL MOTOR CARS

Diesel. Application of Diesels to Railcar Transportation, O. F. Allen. Power, vol. 74, no. 24, Dec. 15, 1931, pp. 864–866, 6 figs. Brief historical review of rail motor car development; Diesel engine application to rail motor car service; Diesel engine drive characteristics.

Switzerland. En marge du probleme des automobiles sur rails (Automobiles on Rails). Bul. Technique de la Suisse Romande, vol. 57, no. 22, Oct. 31, 1931, pp. 276–278, 2 figs. Experiments with Saurer automobile in 1908 show possibilities of pneumatic tires on rails.

Diesel-Electric. New Diesel-Electric Rail Cars. Ry. Gaz., vol. 55, no. 25, Dec. 18, 1931, pp. 776–779. General arrangement and dimensions of rail car; plotted data secured on test run on L.N.E.R., and gradient profile of line concerned; power equipment; automatic features.

250 B.H.P. Oil-Electric Rail Coach. Engineer, vol. 152, no. 3962, Dec. 18, 1931, pp. 658–659, 3 figs. Armstrong, Whitworth have produced standard form of coach, to meet requirements of services in Great Britain; electric transmission consists of d.c. generator, driven by engine supplying current to two traction motors; seating capacity of car, 60; max. speed, 65 mph; 6-cylinder engine is of standard "Armstrong-Sulzer" 4-stroke locomotive type; trials on L.N.E.R. system.